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Hara et al.

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(54) **INFORMATION PROCESSING APPARATUS, COMMUNICATION METHOD AND STORAGE MEDIUM**

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(52) **U.S. Cl.**
CPC *G06F 15/17375* (2013.01)

(58) **Field of Classification Search**
CPC G06F 17/17337; H04L 12/42
USPC 710/34
See application file for complete search history.

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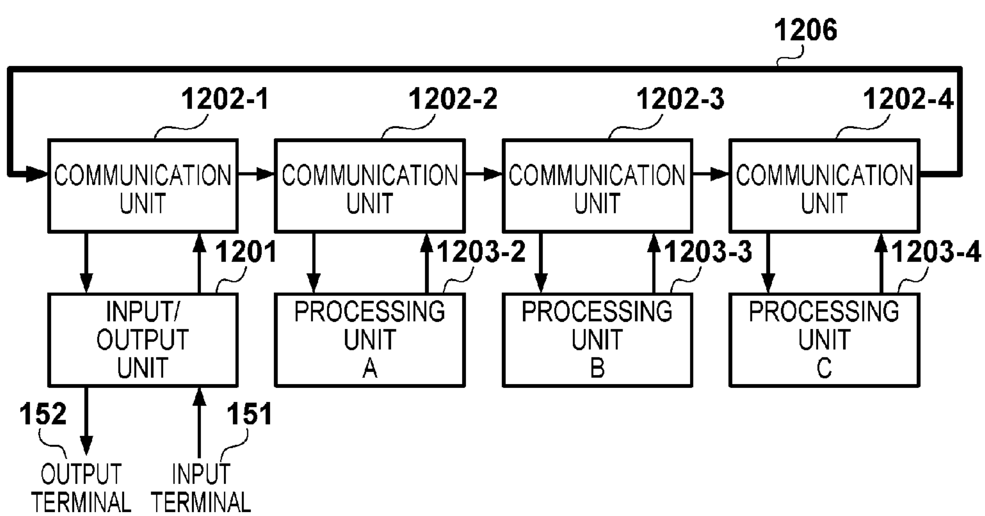
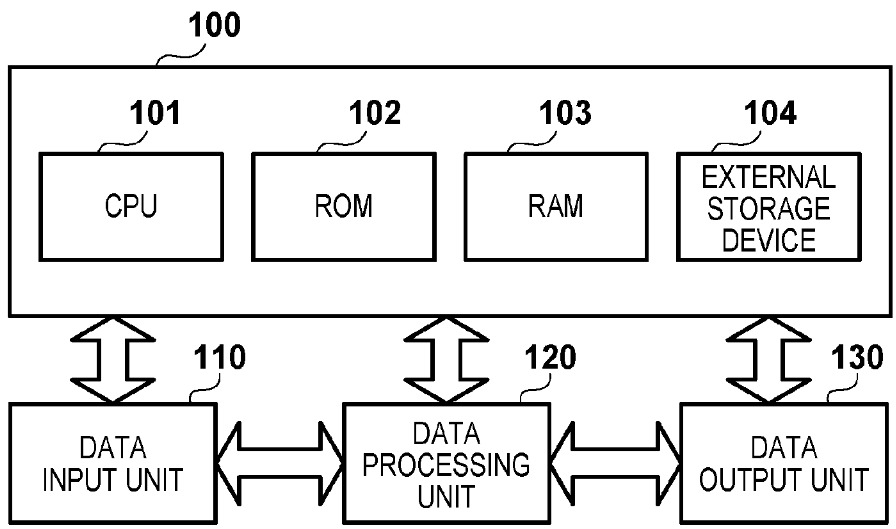
(57) **ABSTRACT**

There is provided an information processing apparatus including a plurality of communication units connected to one another in a ring shape by a bus, each of the plurality of communication units being connected to one of processing units, each of which executes a predetermined process, and transmitting data processed by the one of the processing units to the bus as a packet, the information processing apparatus transferring data between the processing units and processing the data in a predetermined order. Among the plurality of communication units, in at least one communication unit, a packet including a value indicative of suspension of the process is generated when the connected processing unit has suspended a process, and information showing whether or not the generation unit has generated the packet including the value indicative of suspension of the process is stored.

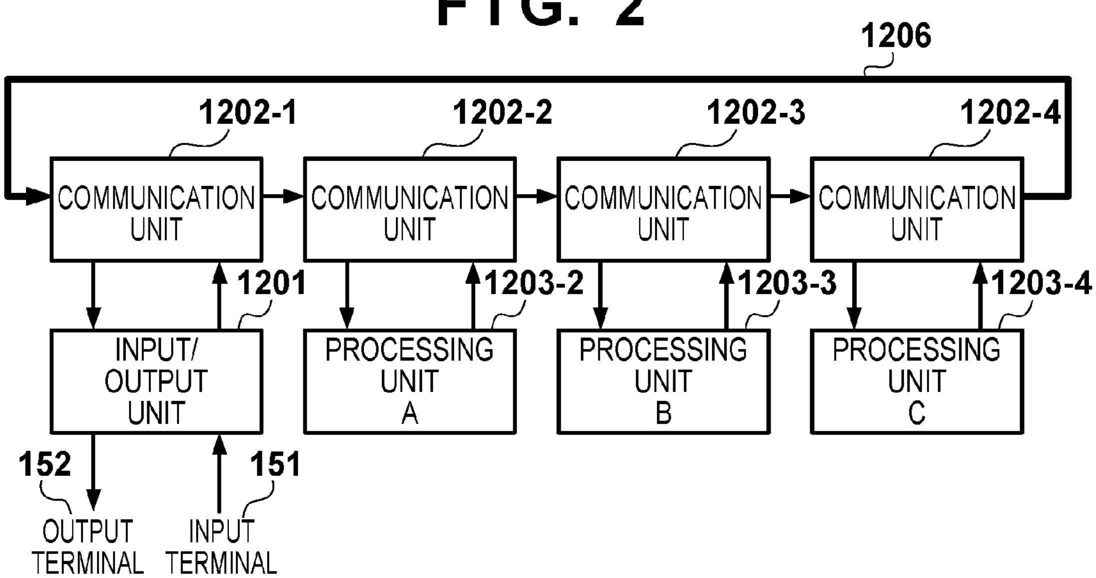
14 Claims, 9 Drawing Sheets



F I G. 1



F I G. 2



F I G. 3

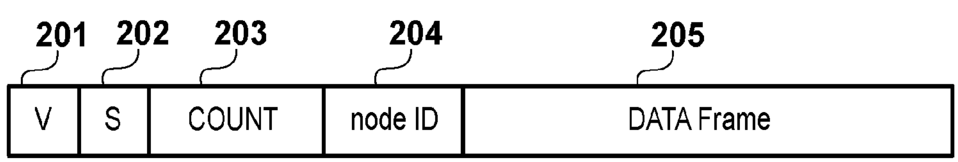


FIG. 4

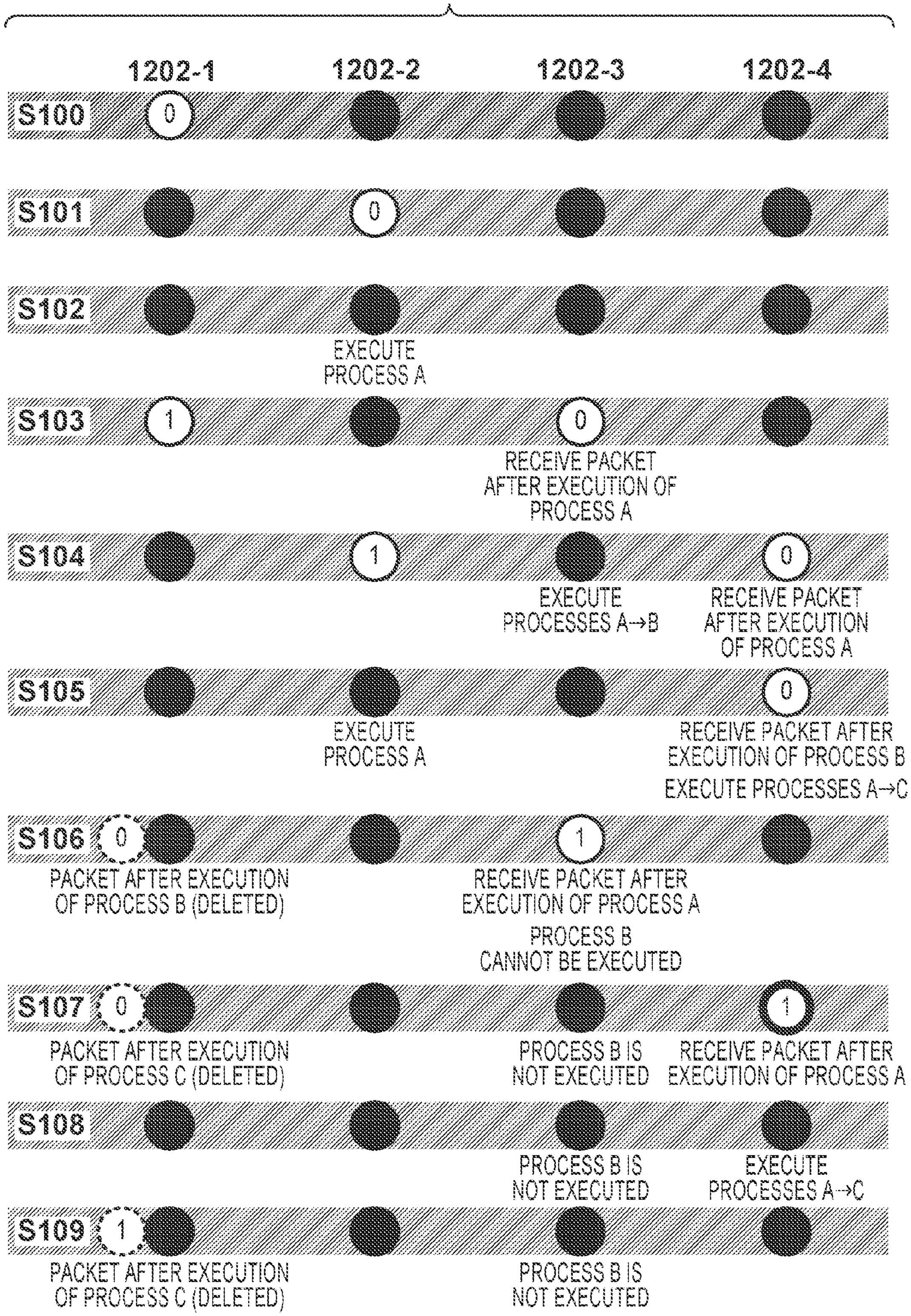

1202-1
1202-2
1202-3
1202-4
S100
0
S101
0
S102
EXECUTE PROCESS A
S103
1
0
RECEIVE PACKET AFTER EXECUTION OF PROCESS A
S104
1
0
EXECUTE PROCESSES A→B
RECEIVE PACKET AFTER EXECUTION OF PROCESS A
S105
0
EXECUTE PROCESS A
RECEIVE PACKET AFTER EXECUTION OF PROCESS B
EXECUTE PROCESSES A→C
S106
0
1
PACKET AFTER EXECUTION OF PROCESS B (DELETED)
RECEIVE PACKET AFTER EXECUTION OF PROCESS A
PROCESS B CANNOT BE EXECUTED
S107
0
1
PACKET AFTER EXECUTION OF PROCESS C (DELETED)
PROCESS B IS NOT EXECUTED
RECEIVE PACKET AFTER EXECUTION OF PROCESS A
S108
PROCESS B IS NOT EXECUTED
EXECUTE PROCESSES A→C
S109
1
PACKET AFTER EXECUTION OF PROCESS C (DELETED)
PROCESS B IS NOT EXECUTED

FIG. 5

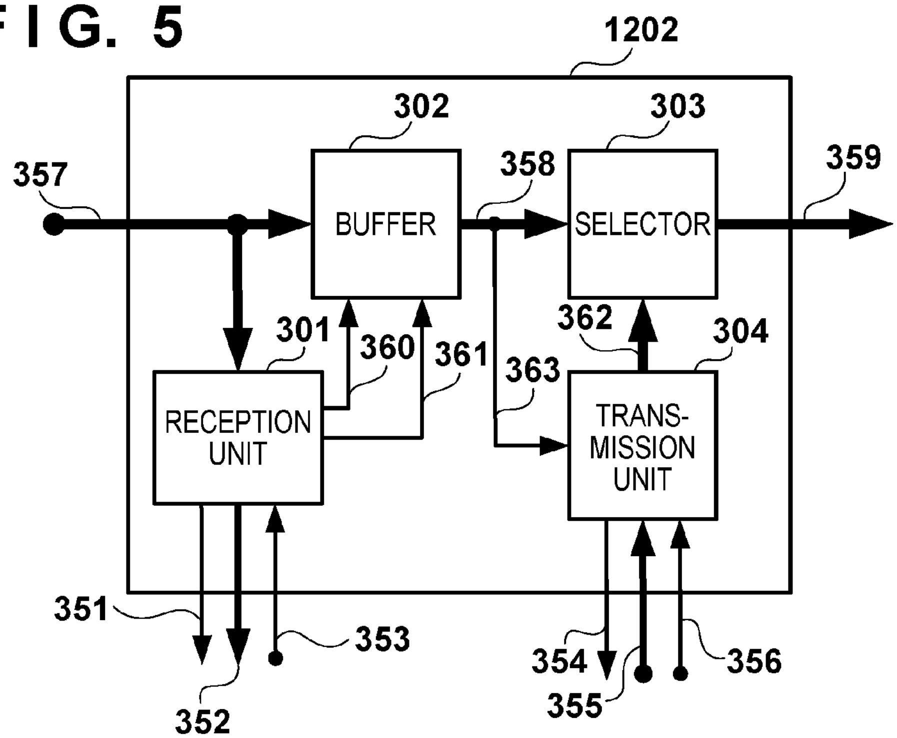
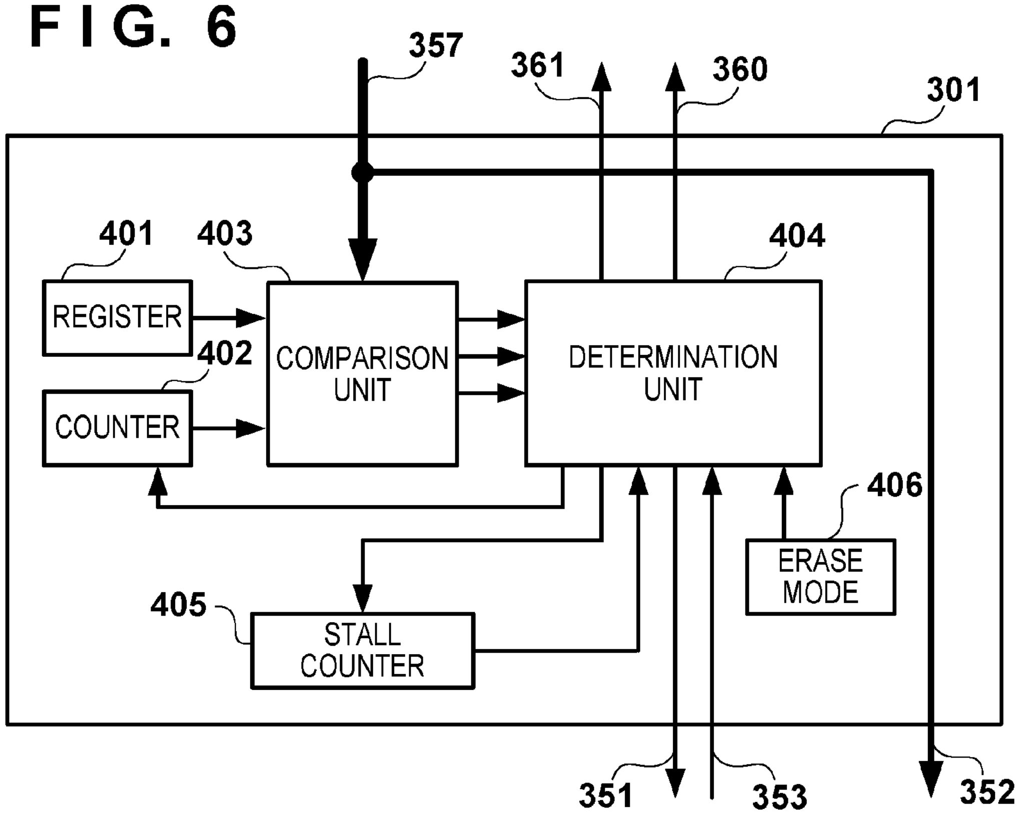

1202
302
303
357
BUFFER
358
SELECTOR
359
301
360
361
362
304
363
RECEPTION UNIT
TRANS-MISSION UNIT
351
353
354
356
355
352

FIG. 6


357
361
360
301
401
403
404
REGISTER
402
COMPARISON UNIT
DETERMINATION UNIT
COUNTER
406
ERASE MODE
405
STALL COUNTER
351
353
352

F I G. 7

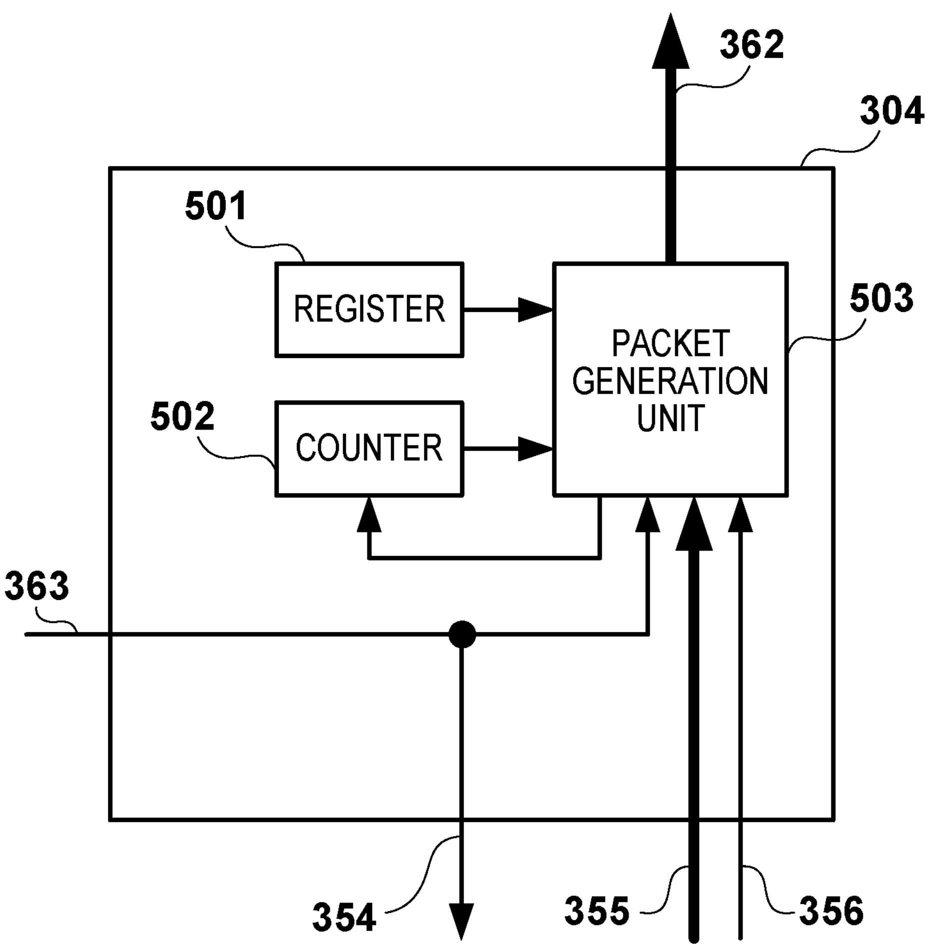

362
304
501
REGISTER
503
PACKET GENERATION UNIT
502
COUNTER
363
354
355
356

FIG. 8A

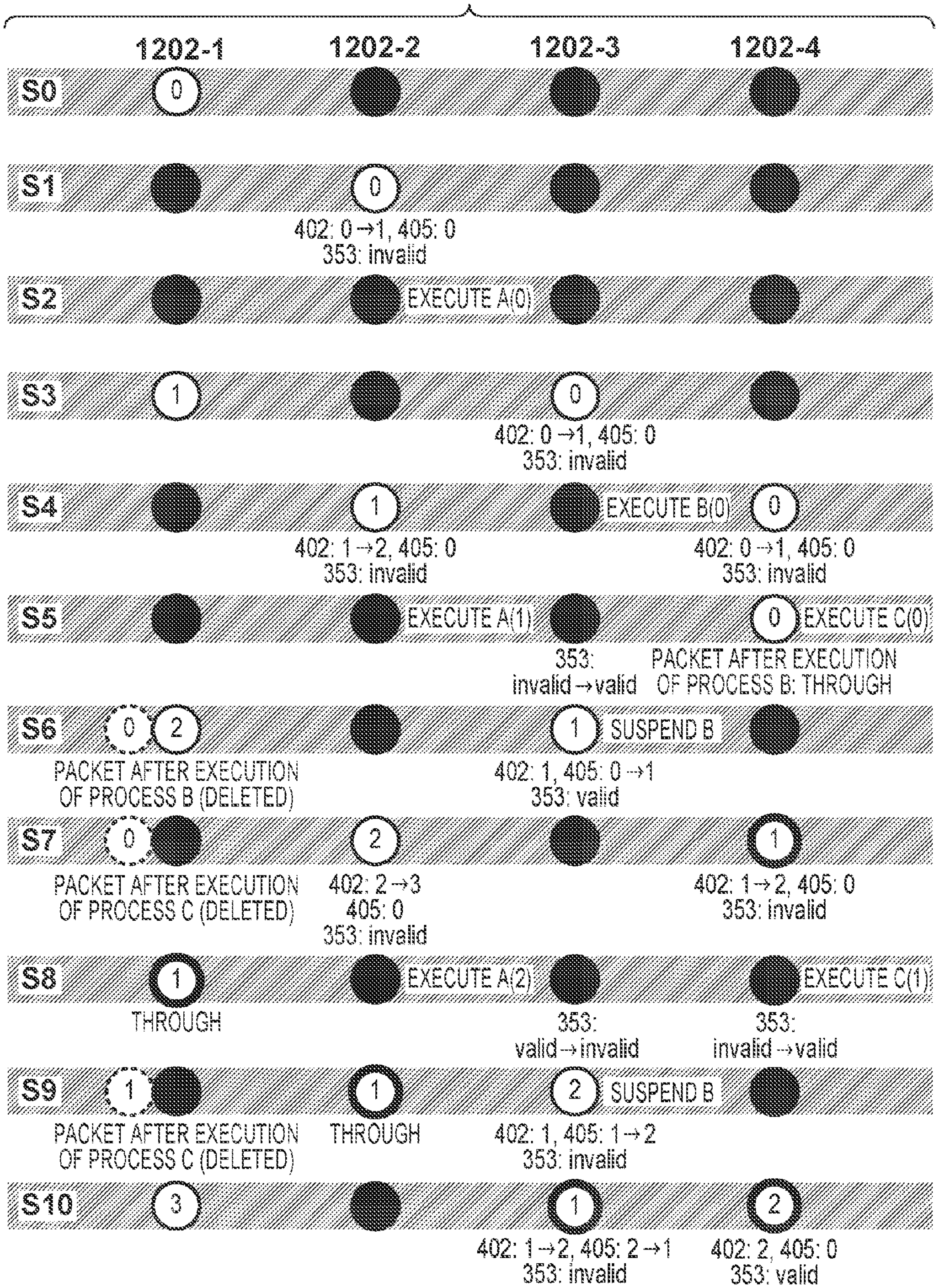
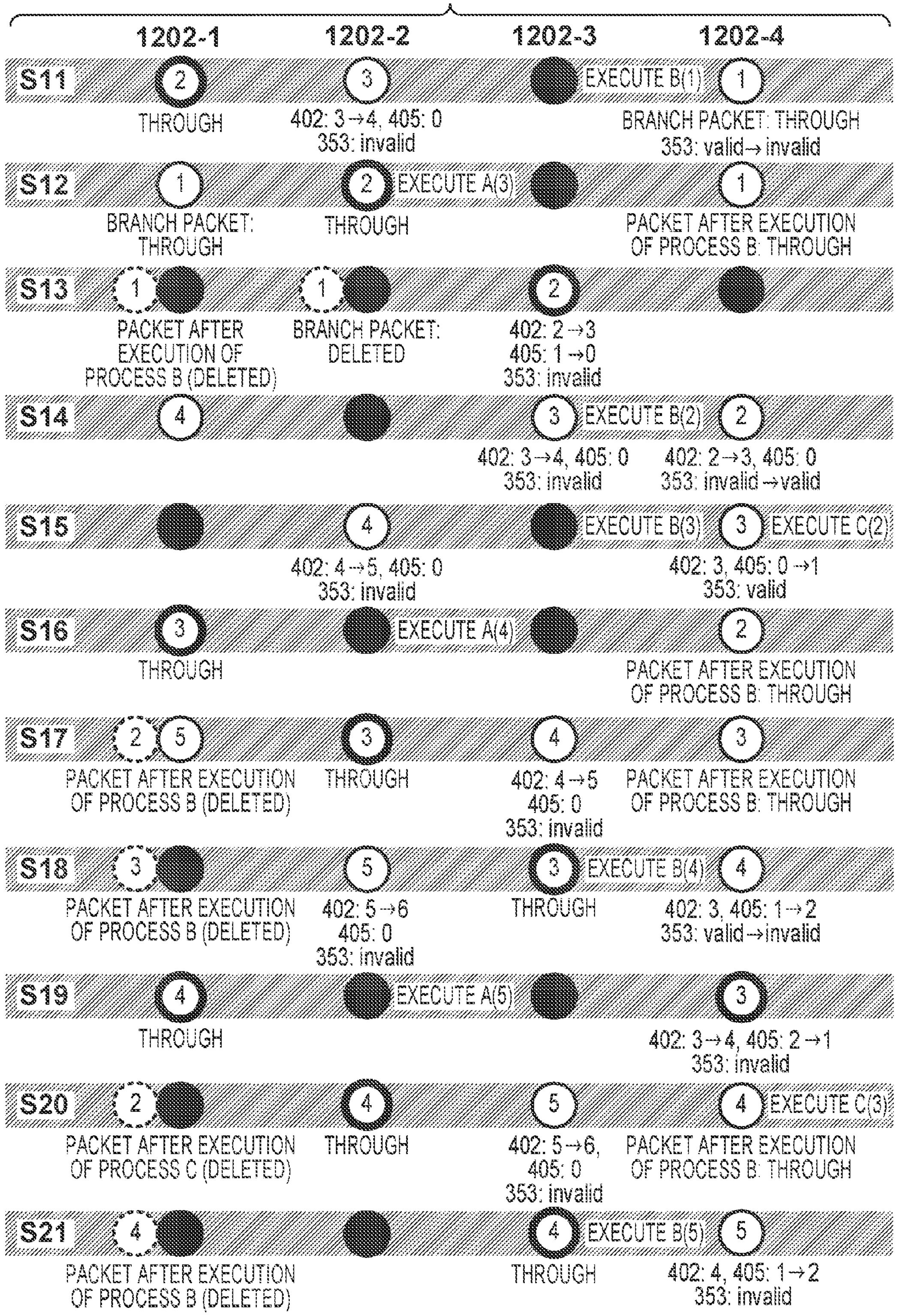
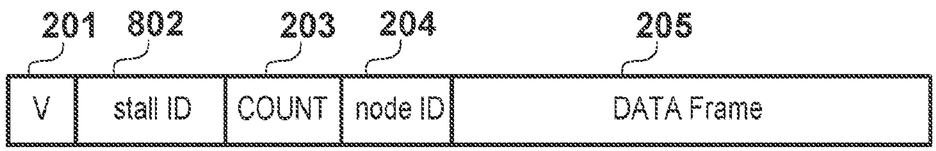

1202-1
1202-2
1202-3
1202-4
S0
0
S1
0
402: 0→1, 405: 0
353: invalid
S2
EXECUTE A(0)
S3
1
0
402: 0→1, 405: 0
353: invalid
S4
1
EXECUTE B(0)
0
402: 1→2, 405: 0
353: invalid
402: 0→1, 405: 0
353: invalid
S5
EXECUTE A(1)
0
EXECUTE C(0)
353:
invalid→valid
PACKET AFTER EXECUTION
OF PROCESS B: THROUGH
S6
0
2
1
SUSPEND B
PACKET AFTER EXECUTION
OF PROCESS B (DELETED)
402: 1, 405: 0→1
353: valid
S7
0
2
1
PACKET AFTER EXECUTION
OF PROCESS C (DELETED)
402: 2→3
405: 0
353: invalid
402: 1→2, 405: 0
353: invalid
S8
1
EXECUTE A(2)
EXECUTE C(1)
THROUGH
353:
valid→invalid
353:
invalid→valid
S9
1
1
2
SUSPEND B
PACKET AFTER EXECUTION
OF PROCESS C (DELETED)
THROUGH
402: 1, 405: 1→2
353: invalid
S10
3
1
2
402: 1→2, 405: 2→1
353: invalid
402: 2, 405: 0
353: valid

FIG. 8B


1202-1
1202-2
1202-3
1202-4
S11
2
3
EXECUTE B(1)
1
THROUGH
402: 3→4, 405: 0
353: invalid
BRANCH PACKET: THROUGH
353: valid→invalid
S12
1
2
EXECUTE A(3)
1
BRANCH PACKET: THROUGH
THROUGH
PACKET AFTER EXECUTION OF PROCESS B: THROUGH
S13
1
1
2
PACKET AFTER EXECUTION OF PROCESS B (DELETED)
BRANCH PACKET: DELETED
402: 2→3
405: 1→0
353: invalid
S14
4
3
EXECUTE B(2)
2
402: 3→4, 405: 0
353: invalid
402: 2→3, 405: 0
353: invalid→valid
S15
4
EXECUTE B(3)
3
EXECUTE C(2)
402: 4→5, 405: 0
353: invalid
402: 3, 405: 0→1
353: valid
S16
3
EXECUTE A(4)
2
THROUGH
PACKET AFTER EXECUTION OF PROCESS B: THROUGH
S17
2
5
3
4
3
PACKET AFTER EXECUTION OF PROCESS B (DELETED)
THROUGH
402: 4→5
405: 0
353: invalid
PACKET AFTER EXECUTION OF PROCESS B: THROUGH
S18
3
5
3
EXECUTE B(4)
4
PACKET AFTER EXECUTION OF PROCESS B (DELETED)
402: 5→6
405: 0
353: invalid
THROUGH
402: 3, 405: 1→2
353: valid→invalid
S19
4
EXECUTE A(5)
3
THROUGH
402: 3→4, 405: 2→1
353: invalid
S20
2
4
5
4
EXECUTE C(3)
PACKET AFTER EXECUTION OF PROCESS C (DELETED)
THROUGH
402: 5→6,
405: 0
353: invalid
PACKET AFTER EXECUTION OF PROCESS B: THROUGH
S21
4
4
EXECUTE B(5)
5
PACKET AFTER EXECUTION OF PROCESS B (DELETED)
THROUGH
402: 4, 405: 1→2
353: invalid

F I G. 9


201
802
203
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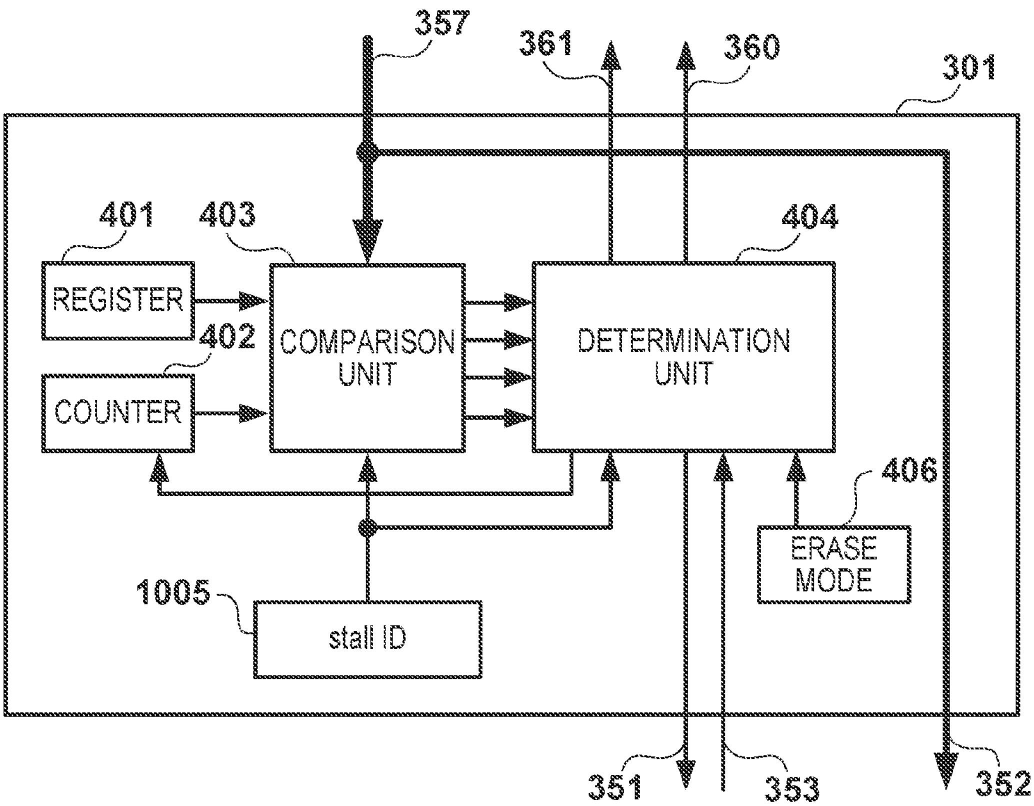
205
V
stall ID
COUNT
node ID
DATA Frame

F I G. 10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403
404
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DETERMINATION UNIT
COUNTER
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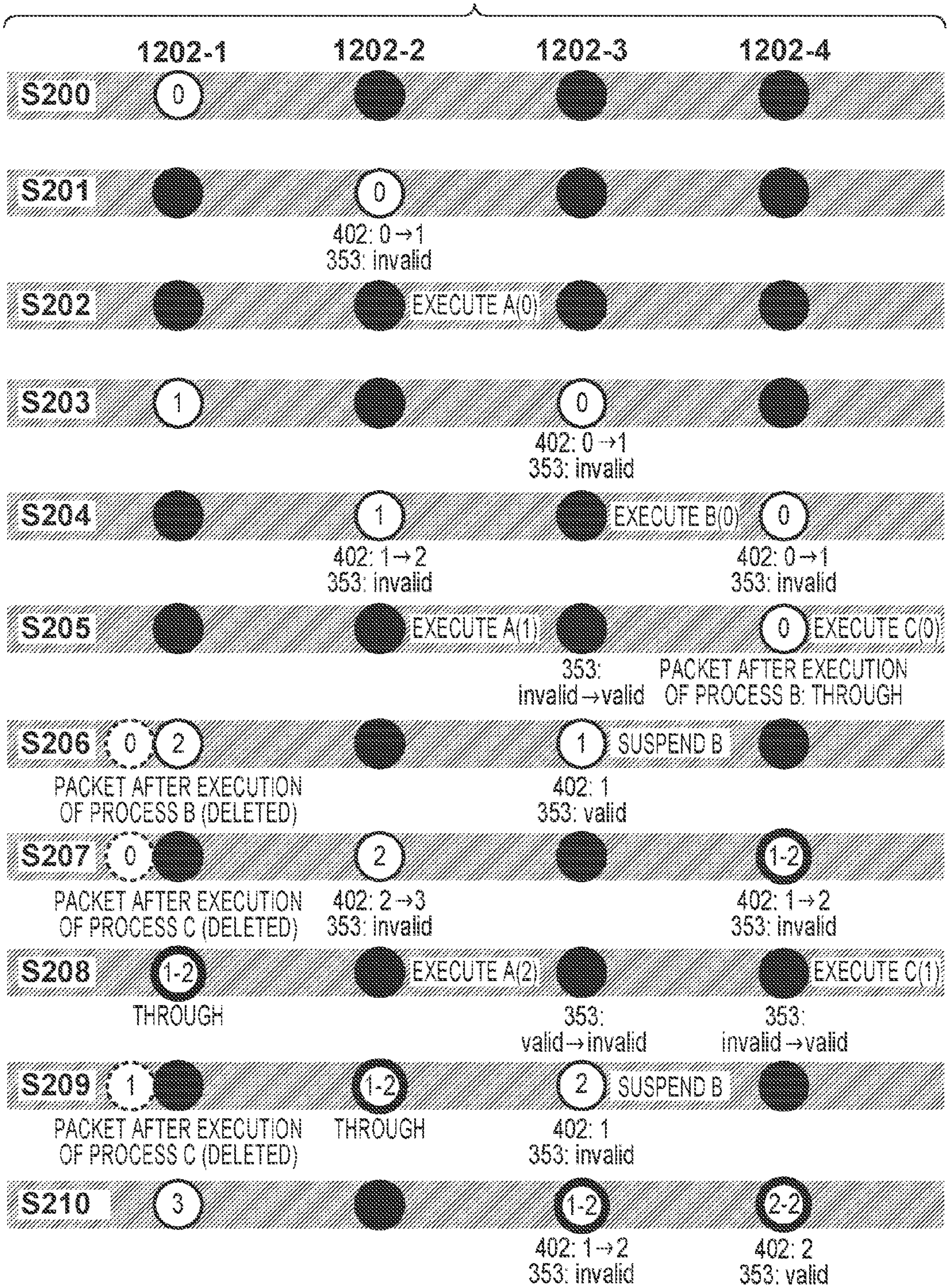
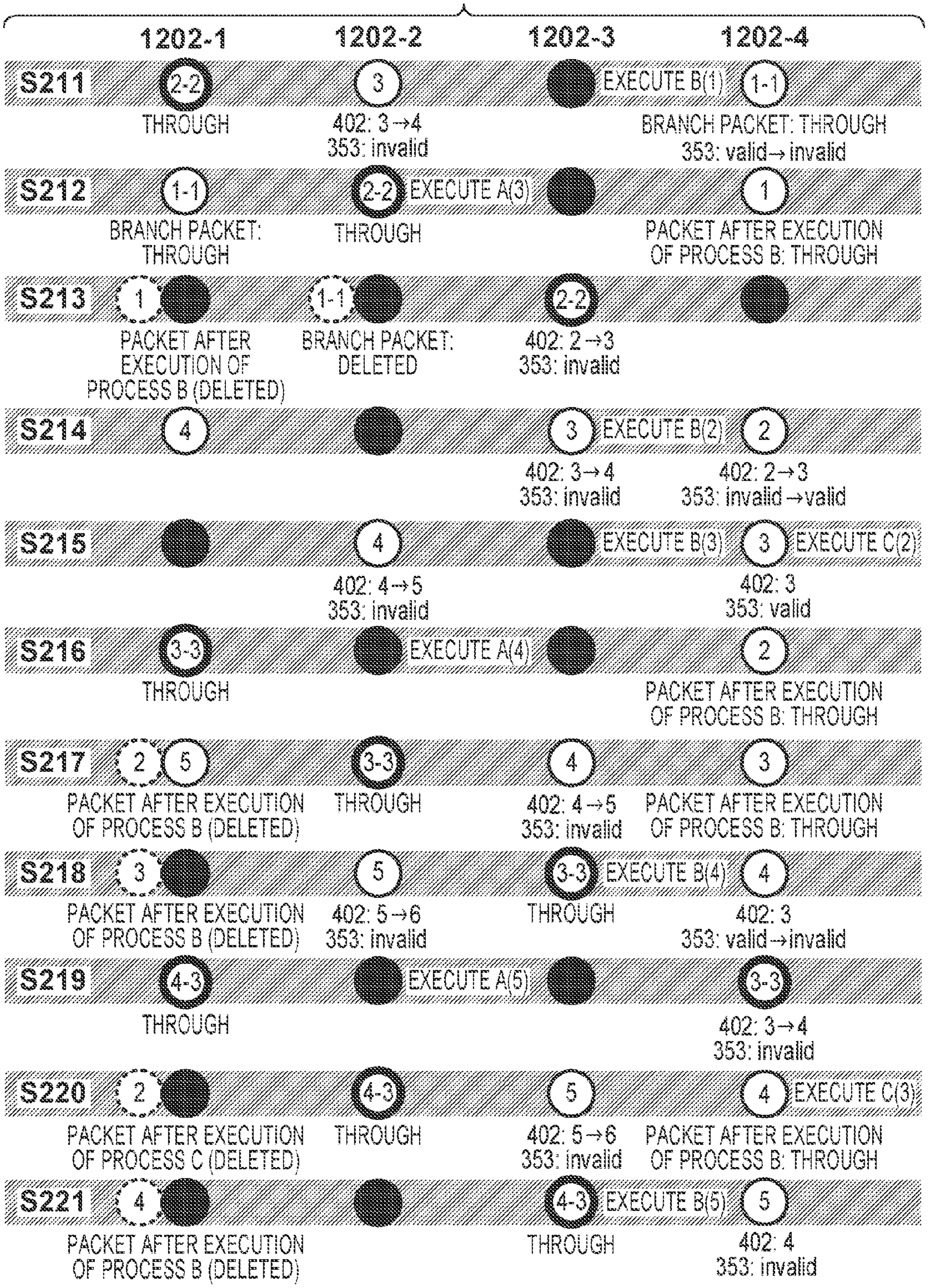
ERASE MODE
1005
stall ID
351
353
352

FIG. 11A



1202-1
1202-2
1202-3
1202-4
S200
0
S201
0
402: 0→1
353: invalid
S202
EXECUTE A(0)
S203
1
0
402: 0→1
353: invalid
S204
1
EXECUTE B(0)
0
402: 1→2
353: invalid
402: 0→1
353: invalid
S205
EXECUTE A(1)
0
EXECUTE C(0)
353:
invalid→valid
PACKET AFTER EXECUTION
OF PROCESS B: THROUGH
S206
0
2
1
SUSPEND B
PACKET AFTER EXECUTION
OF PROCESS B (DELETED)
402: 1
353: valid
S207
0
2
1-2
PACKET AFTER EXECUTION
OF PROCESS C (DELETED)
402: 2→3
353: invalid
402: 1→2
353: invalid
S208
1-2
EXECUTE A(2)
EXECUTE C(1)
THROUGH
353:
valid→invalid
353:
invalid→valid
S209
1
1-2
2
SUSPEND B
PACKET AFTER EXECUTION
OF PROCESS C (DELETED)
THROUGH
402: 1
353: invalid
S210
3
1-2
2-2
402: 1→2
353: invalid
402: 2
353: valid

FIG. 11B


1202-1
1202-2
1202-3
1202-4
S211
2-2
THROUGH
3
402: 3→4
353: invalid
EXECUTE B(1)
1-1
BRANCH PACKET: THROUGH
353: valid→invalid
S212
1-1
BRANCH PACKET: THROUGH
2-2
EXECUTE A(3)
THROUGH
1
PACKET AFTER EXECUTION OF PROCESS B: THROUGH
S213
1
PACKET AFTER EXECUTION OF PROCESS B (DELETED)
1-1
BRANCH PACKET: DELETED
2-2
402: 2→3
353: invalid
S214
4
3
EXECUTE B(2)
402: 3→4
353: invalid
2
402: 2→3
353: invalid→valid
S215
4
402: 4→5
353: invalid
EXECUTE B(3)
3
EXECUTE C(2)
402: 3
353: valid
S216
3-3
THROUGH
EXECUTE A(4)
2
PACKET AFTER EXECUTION OF PROCESS B: THROUGH
S217
2
5
PACKET AFTER EXECUTION OF PROCESS B (DELETED)
3-3
THROUGH
4
402: 4→5
353: invalid
3
PACKET AFTER EXECUTION OF PROCESS B: THROUGH
S218
3
PACKET AFTER EXECUTION OF PROCESS B (DELETED)
5
402: 5→6
353: invalid
3-3
EXECUTE B(4)
THROUGH
4
402: 3
353: valid→invalid
S219
4-3
THROUGH
EXECUTE A(5)
3-3
402: 3→4
353: invalid
S220
2
PACKET AFTER EXECUTION OF PROCESS C (DELETED)
4-3
THROUGH
5
402: 5→6
353: invalid
4
EXECUTE C(3)
PACKET AFTER EXECUTION OF PROCESS B: THROUGH
S221
4
PACKET AFTER EXECUTION OF PROCESS B (DELETED)
4-3
EXECUTE B(5)
THROUGH
5
402: 4
353: invalid

INFORMATION PROCESSING APPARATUS, COMMUNICATION METHOD AND STORAGE MEDIUM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an information processing apparatus, communication method and storage medium that transfer and process data using a ring-shaped bus.

2. Description of the Related Art

There is a conventional method for achieving high-speed pipeline processing, whereby a sequence of data processing constituting the pipeline processing is divided into groups, the groups of data processing are assigned to a plurality of modules, and the plurality of modules are connected by a bus in the order of the flow of processing (Japanese Patent Laid-Open No. 5-081178). However, when modules are connected by a physical bus, it is difficult to change the order of pipeline processing, e.g. change processes A→B→C to processes A→C→B. Note that the above assignment is made to avoid overlapping of processes A, B and C.

In image processing, the efficiency of processing may be improved by changing the order of the sequence of processing. For example, in the case where an image is output to an output apparatus, if the number of pixels in the input image is greater than the number of pixels of the output apparatus, it would be efficient to process the image after reducing the number of pixels therein in the upstream process close to the start of processing. On the other hand, if the number of pixels in the input image is smaller than the number of pixels of the output apparatus, it is better to process the image having the small number of pixels without executing resolution conversion, and then increase the number of pixels in the image by executing resolution conversion in the downstream process immediately before the output.

In some cases, data defined in a certain space (e.g. an input device space) is processed after being converted into a standard space (e.g. a CIELAB color space), and the processed data is converted into another space (e.g. an output device space). In such cases, the space conversion units at the input side and the output side execute processing (one-dimensional LUT, matrix operation, three-dimensional LUT, etc.) in the reverse order. That is to say, if the order of processing can be changed, the input side and the output side may be able to share the same processing module. One way to enable a change in the processing order is to connect processing circuits by a ring-shaped bus (hereinafter referred to as a ring bus) (Japanese Patent Laid-Open No. 1-023340 and No. 2-283142).

However, in the case of a branch process where two processes A→B and A→C are simultaneously executed in pipeline processing composed of processes A→B→C, if a processing module at one side suspends a packet without processing the same, that processing module cannot be identified. This gives rise to the problem that the suspended packet cannot be deleted at a correct timing and is therefore stalled on the ring bus. Furthermore, should the suspended packet be deleted before data included in the suspended packet is processed by another processing module that is supposed to process that data, the subsequent packets cannot be processed. This gives rise to the problem that the ring bus ends up in a deadlock.

The present invention provides technology for executing a branch process without losing data in a data path control mechanism in which a plurality of processing units are connected by a ring-shaped bus.

SUMMARY OF THE INVENTION

According to one aspect of the present invention, there is provided an information processing apparatus including a plurality of communication units connected to one another in a ring shape by a bus, each of the plurality of communication units being connected to one of processing units, each of which executes a predetermined process, and transmitting data processed by the one of the processing units to the bus as a packet, the information processing apparatus transferring data between the processing units and processing the data in a predetermined order, wherein among the plurality of communication units, at least one communication unit comprises: a generation unit configured to, when the connected processing unit has suspended a process, generate a packet including a value indicative of suspension of the process; and a storage unit configured to store information showing whether or not the generation unit has generated the packet including the value indicative of suspension of the process.

According to one aspect of the present invention, there is provided an information processing apparatus including a plurality of communication units connected to one another in a ring shape by a bus, each of the plurality of communication units being connected to one of processing units, each of which executes a predetermined process, and transmitting data processed by the one of the processing units to the bus as a packet, the information processing apparatus transferring data between the processing units and processing the data in a predetermined order, wherein among the plurality of communication units, at least one communication unit comprises: a storage unit configured to store information for identifying the connected processing unit; and a generation unit configured to, when the connected processing unit has suspended a process, generate a packet including the information for identifying the connected processing unit.

According to one aspect of the present invention, there is provided a communication method used in an information processing apparatus including a plurality of communication units connected to one another in a ring shape by a bus, each of the plurality of communication units being connected to one of processing units, each of which executes a predetermined process, and transmitting data processed by the one of the processing units to the bus as a packet, the information processing apparatus transferring data between the processing units and processing the data in a predetermined order, wherein in at least one communication unit among the plurality of communication units, the communication method comprises: generating, by a generation unit, a packet including a value indicative of suspension of a process when the connected processing unit has suspended the process; and storing, by a storage unit, information showing whether or not the packet including the value indicative of suspension of the process has been generated in the generating step.

According to one aspect of the present invention, there is provided a communication method used in an information processing apparatus including: a plurality of communication units connected to one another in a ring shape by a bus; and a storage unit, each of the plurality of communication units being connected to one of processing units, each of which executes a predetermined process, and transmitting data processed by the one of the processing units to the bus as a packet, the information processing apparatus transferring data between the processing units and processing the data in a predetermined order, the storage unit storing therein information for identifying the processing unit connected to at least one communication unit among the plurality of communication units, wherein in the at least one communication unit, the communication method comprises: generating, by a generation unit, a packet including the information for identifying the connected processing unit when the connected processing unit has suspended a process.

Further features of the present invention will be apparent from the following description of exemplary embodiments with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a configuration of an information processing apparatus.

FIG. **2** shows a configuration of a data processing unit.

FIG. **3** shows a structure of a packet pertaining to the first embodiment.

FIG. **4** shows operations of a conventional data path control mechanism.

FIG. **5** shows a configuration of a communication unit pertaining to the first embodiment.

FIG. **6** shows a configuration of a reception unit pertaining to the first embodiment.

FIG. **7** shows a configuration of a transmission unit pertaining to the first embodiment.

FIG. **8**A shows operations of a data path control mechanism pertaining to the first embodiment.

FIG. **8**B shows operations of the data path control mechanism pertaining to the first embodiment.

FIG. **9** shows a structure of a packet pertaining to the second embodiment.

FIG. **10** shows a configuration of a reception unit pertaining to the second embodiment.

FIG. **11**A shows operations of a data path control mechanism pertaining to the second embodiment.

FIG. **11**B shows operations of the data path control mechanism pertaining to the second embodiment.

DESCRIPTION OF THE EMBODIMENTS

An exemplary embodiment(s) of the present invention will now be described in detail with reference to the drawings. It should be noted that the relative arrangement of the components, the numerical expressions and numerical values set forth in these embodiments do not limit the scope of the present invention unless it is specifically stated otherwise.

<First Embodiment>

(Configuration of Information Processing Apparatus)

FIG. **1** shows an example of a configuration of an information processing apparatus pertaining to the present embodiment. A control unit **100** includes a CPU **101** for arithmetic control, a ROM **102** that stores therein fixed data and programs, a RAM **103** used to temporarily store data and load programs, and an external storage device **104** that holds external data.

A data input unit **110** imports data to be processed. The data input unit **110** may be, for example, an image reading apparatus constituted by devices such as an image scanner and an A/D converter, or an audio input apparatus constituted by devices such as a microphone and an A/D converter. Alternatively, the data input unit **110** may be a reception unit that acquires data from an input device. As will be described later, a data processing unit **120** executes parallel processing using a plurality of processing modules. The data processing unit **120** processes image data and the like. However, the target of processing by the data processing unit **120** is not limited to this, but may be any data appropriate for a sequence of data processing such as pipeline processing. A data output unit **130** outputs processed data to the outside. The data output unit **130** may be, for example, an image output apparatus including a printer device that converts image data into dotted patterns for printing and outputs the dotted patterns, or an audio output apparatus that outputs audio data via a D/A converter and the like. Alternatively, the data output unit **130** may simply be an interface for transmitting data to an external device.

Upon receiving data input to the data input unit **110**, the control unit **100** may process the data in the CPU **101**, or may temporarily store the data as-is in the RAM **103** or the external storage device **104**.

The data processing unit **120** may directly receive and process data input from the data input unit **110**, or may process data upon receiving an instruction and the data from the control unit **100**. The output from the data processing unit **120** may be transmitted to the control unit **100**, or may be directly transmitted to the data output unit **130**. The details of processing of the data processing unit **120** are set by the control unit **100** in advance, and the data processing unit **120** executes processing that has been set in correspondence with supplied data.

(Configuration of Data Processing Unit)

FIG. **2** is a block diagram showing an example of a configuration of the data processing unit **120** pertaining to the present embodiment, presenting a schematic configuration of a data path control mechanism in which processing modules are connected by a ring-shaped bus. Hereinafter, the ring-shaped bus is referred to as a "ring bus". In FIG. **2**, **1201** denotes a data input/output unit, **1202-1** to **1202-4** denote communication units, and **1203-2** to **1203-4** denote data processing units that are provided in one-to-one correspondence with the communication units **1202-2** to **1202-4**.

Each of the communication units **1202-1** to **1202-4** is connected to a neighboring communication unit (note, the communication unit **1202-4** is connected to the communication unit **1202-1**), and transmits data received from a certain direction (first direction) to the other direction (second direction) as a part of the ring bus **1206**. That is to say, the communication units **1202-1** to **1202-4** constitute the ring bus **1206** and exchange data between the ring bus **1206** and the input/output unit **1201** or the processing units **1203**.

Data input from an input terminal **151** is input to the communication unit **1202-1** via the input/output unit **1201**. The input data is packetized and carried over the ring bus **1206** in one direction. The communication units **1202** import necessary packets from the ring bus **1206** in accordance with information that has been set in advance, extract data from the imported packets, and input the extracted data to the processing units **1203** if the processing units **1203** can process the extracted data. The processing units **1203** execute predetermined data processing (e.g. color space conversion and resolution conversion) and output the processed data to the communication units **1202**. If the processed data can be output to the ring bus **1206**, it is packetized by the communication units **1202** and transmitted to the ring bus **1206**. In this way, with the communication units **1202-2** to **1202-4** appropriately importing data and transmitting the processed data in the set order, the processing units **1203-2** to **1203-4** process the data in sequence. When data processing set in correspondence with data is completed, the data is imported by the communication unit **1202-1** and output from an output terminal **152** via the input/output unit **1201**. Note that the processing units **1203-2** to **1203-4** execute processes A, B and C, respectively.

Note that the input/output unit **1201** serves as an interface for an external device (or module), and may be omitted if the communication unit **1202-1** can directly exchange information with the external device. Furthermore, the input/output unit **1201** may serve both as an input unit and an output unit like it is in the present embodiment. Alternatively, an input unit and an output unit may be connected to different communication units **1202** on the ring bus, respectively. Furthermore, a plurality of input units and output units may be provided.

(Data Structure of Packet)

FIG. **3** shows a data structure of a packet carried over the ring bus **1206**. In FIG. **3**, **201** denotes a valid flag indicating that the packet is valid, **202** denotes a stall flag indicating that the packet has been received and suspended, **203** denotes a count value indicating the order of transmission of data, **204** denotes a node ID indicating a connection ID for identifying logical connection of data, and **205** denotes data that is input or output to the communication units.

The communication units **1202** analyze a packet transmitted to the ring bus **1206** and determine whether or not the valid flag **201** is valid and whether or not the ID **204** and the count value **203** match the values managed in the communication units **1202**. When the values match, the communication units **1202** determine whether or not the processing units **1203** directly connected thereto can process the received data. That is to say, in the case of the communication unit **1202-2** shown in FIG. **2**, it determines whether or not the corresponding processing unit **1203-2** can process the data. When determining that the corresponding processing units **1203** can process the data, the communication units **1202** transmit the data included in the packet to the corresponding processing units **1203**. At the same time, each communication unit **1202** transmits a packet in which the valid flag **201** and the stall flag **202** are set to be invalid (hereinafter referred to as an "empty packet") to another communication unit **1202** that is connected thereto and downstream thereof (in the subsequent stage) along the ring bus **1206**.

Under certain setting, even when the data is transmitted to the processing units **1203**, the packet may be transmitted downstream with the valid flag **201** remaining to be valid. Hereinafter, this setting is referred to as "erase mode". In the case where the erase mode is invalid, each communication unit **1202** transmits the packet in which the valid flag **201** remains to be valid to another communication unit **1202** that is connected thereto and downstream thereof, even when the data is transmitted to the corresponding processing unit **1203**. This setting is used in the branch process, which will be described later. However, the stall flag **202** is set to be invalid. The above operation prevents a suspended packet, which will be described later, from being needlessly retained on the ring bus **1206**.

There are cases where data in the packet received by the communication units **1202** cannot be processed by the processing units **1203** corresponding to the communication units **1202**, even when the valid flag **201** is valid and the ID **204** and the count value **203** match the values managed in the communication units **1202**. In such cases, a packet in which the stall flag **202** is validated (hereinafter referred to as a suspended packet) is transmitted to the ring bus **1206**. Similarly, the communication units **1202** transmit the suspended packet to the ring bus **1206** also when the valid flag **201** is valid and the ID **204** matches the value managed in the communication units **1202** but the count value **203** does not match the value managed in the communication units **1202**. On the other hand, in the case where the valid flag **201** in the received packet is valid but the ID **204** in the received packet does not match the value managed in the communication units **1202**, the communication units **1202** transmit the packet as-is to the ring bus **1206** without changing the contents of the packet.

The communication unit **1202-1** manages two pairs of ID and count value that are referenced when determining whether or not they match the ID **204** and the count value **203** in the input packet. In this way, packets that have been processed through two data flows can be received and output to the output terminal **152** in the branch process described later.

With reference to FIG. **4**, the following describes a specific example of operations of the data path control mechanism shown in FIG. **2** for the case of the branch process where two processes A→B and A→C are simultaneously executed. Note that in FIG. **4**, the numbers enclosed in circles denote valid packets (in which the valid flag **201** is valid), and the numbers in the circles denote the count value **203** in the packets. Also, filled circles denote empty packets, and a circle with a bold outline denotes a packet in which the stall flag **202** is valid.

First, the CPU (not shown in the figure) or the like sets the value of ID stored in the communication units **1202** to a value for execution of the branch process. That is to say, in the communication unit **1202-2**, the value of ID is set so as to process data input from the communication unit **1202-1** via the input/output unit **1201**. Furthermore, in the communication units **1202-3** and **1202-4**, the value of ID is set so as to process data that has been processed by the processing unit **1203-2** corresponding to the communication unit **1202-2**. Moreover, in the communication unit **1202-3**, the erase mode is set to be invalid. In this way, a valid packet can be output to the communication unit **1202-4** that is downstream of the communication unit **1202-3**, even when the data is transmitted to the processing unit **1203-3** as the processing unit **1203-3** can process the data. In any other communication unit **1202**, the erase mode is set to be valid.

First, the communication unit **1202-1** acquires data from the input terminal **151** via the input/output unit **1201** (S**100**). The acquired data is packetized and input to the communication unit **1202-2** via the ring bus **1206** (S**101**). At this time, the valid flag **201** is valid and the stall flag **202** is invalid in the packet. Data in the input packet is input to the processing unit **1203-2** because the valid flag **201** in the input packet is valid, the ID **204** and the count value **203** in the input packet match the values managed in the communication unit **1202-2**, and the processing unit **1203-2** can process the data. The processing unit **1203-2** executes process A (S**102**). The processed data is output to the ring bus **1206** as a packet and input to the communication unit **1202-3** (S**103**).

The communication unit **1202-3** outputs data in the input packet to the processing unit **1203-3** because the valid flag **201** in the input packet is valid, the ID **204** and the count value **203** in the input packet match the values managed in the communication unit **1202-3**, and the processing unit **1203-3** can process the data. The processing unit **1203-3** executes process B on the input data (S**104**). At the same time, as the erase mode is invalid in the communication unit **1202-3**, the input packet is output as-is to the communication unit **1202-4** that is downstream of the communication unit **1202-3** (S**104**). The data processed by the processing unit **1203-3** is output to the ring bus **1206** as a packet (S**105**), and the data is output to the output terminal **152** via the communication unit **1202-4**, the communication unit **1202-1** and the input/output unit **1201** (S**106**).

The packet that was input to the communication unit **1202-3** and output therefrom as-is is input to the communication unit **1202-4** (S**104**). Data included in the input packet is input to the processing unit **1203-4** and process C is executed on the data because the valid flag **201** in the input packet is valid, the ID **204** and the count value **203** in the input packet match the values managed in the communication unit **1202-4**, and the processing unit **1203-4** can process the data

(S**105**). The processed data is output to the ring bus **1206** as a packet, and output to the output terminal **152** via the communication unit **1202-1** and the input/output unit **1201** (S**107**).

A description is now given of the case where a suspended packet occurs in a similar branch process because the processing units **1203-2** and **1203-4** can process data but the processing unit **1203-3** cannot process data. Note that the following description uses a packet including the **1**st data as an example. In a similar manner as the above-described example, data input from the input terminal **151** is input to the communication unit **1202-2** via the input/output unit **1201** and the communication unit **1202-1**, and process A is executed on the input data (S**103** to S**105**). The processed data is output to the ring bus **1206** as a packet and input to the communication unit **1202-3** (S**106**). At this time, the valid flag **201** is valid and the stall flag **202** is invalid in the packet.

The valid flag **201** in the input packet is valid, and the ID **204** and the count value **203** in the input packet match the values managed in the communication unit **1202-3**. However, the processing unit **1203-3** corresponding to the communication unit **1202-3** cannot process the data. Therefore, the stall flag **202** in the input packet is set to be valid, and the input packet is transmitted to the ring bus **1206** as a suspended packet (S**107**).

The valid flag **201** in the packet transmitted from the communication unit **1202-3** is valid, the ID **204** and the count value **203** in the packet match the values managed in the communication unit **1202-4**, and the processing unit **1203-4** corresponding to the communication unit **1202-4** can process data in the packet. Therefore, the data in the packet is input to the processing unit **1203-4**, and process C is executed on the data (S**108**). On the other hand, as the erase mode is valid in the communication unit **1202-4**, the communication unit **1202-4** outputs an empty packet to the communication unit **1202-1** via the ring bus **1206** (S**108**). Thereafter, the data processed by the processing unit **1203-4** is output to the ring bus **1206** as a packet, and then output to the output terminal **152** via the communication unit **1202-1** (S**109**).

In the present example, process B cannot be executed because the suspended packet that was input from the communication unit **1202-3** to be processed in process B was deleted and an empty packet was generated. As such, the problem with the branch process is that data for which processing has been suspended in another branch may be deleted. In view of this, the present embodiment provides a configuration for handling the above problem.

(Configuration of Communication Unit)

FIG. **5** is a block diagram showing a schematic configuration of a communication unit **1202**. As shown in FIG. **5**, the communication unit **1202** includes a reception unit **301**, a buffer **302**, a selector **303**, and a transmission unit **304**. The communication unit **1202** also includes an input terminal **357** and an output terminal **359** via which it is connected to neighboring communication units **1202**. More specifically, the input terminal **357** and the output terminal **359** are respectively connected to the output terminal **359** and the input terminal **357** of the neighboring communication units **1202**. The plurality of communication units **1202-1** to **1202-4** are connected by the ring bus **1206** in this manner. In the following description, a neighboring communication unit **1202** on the ring bus **1206** is referred to as an upstream neighboring communication unit **1202** if it is connected via the input terminal **357**, and as a downstream neighboring communication unit **1202** if it is connected via the output terminal **359**. The communication unit **1202** also includes signal lines **351** to **356** via which it is connected to a corresponding processing unit **1203** (one of the processing units **1203-2** to **1203-4**).

A packet input from an upstream neighboring communication unit **1202** is temporarily held in the buffer **302**, and output to the selector **303** in the next clock cycle. The reception unit **301** monitors the packet from the input terminal **357** and determines whether or not the valid flag **201** is valid and whether or not the ID **204** and the count value **203** match the values held in the reception unit **301**. The reception unit **301** also determines whether or not the processing unit **1203** connected thereto can process data. More specifically, if the stall signal is not valid on the signal line **353**, the reception unit **301** determines that the processing unit **1203** can process the data and therefore the data can be input to the processing unit **1203**.

The reception unit **301** imports the data in the input packet if the data can be input to the processing unit **1203**, the valid flag **201** in the input packet is valid, and the ID **204** and the count value **203** in the input packet match the values held in the reception unit **301**. At this time, the reception unit **301** validates the valid signal on the signal line **351** and outputs the imported data to the processing unit **1203** via the signal line **352**. Furthermore, once the data in the packet has been imported, the reception unit **301** increments the count value appended to the data managed in the reception unit **301**. At the same time, the reception unit **301** executes control to clear (invalidate) the valid flag **201** in the packet stored in the buffer **302** via a signal line **360**. The reception unit **301** also sets the value of the stall flag **202** in the packet stored in the buffer **302** via a signal line **361**. The specifics of operations for the above control will be described later.

Via a signal line **363**, the transmission unit **304** monitors the valid flag **201** in the packet output from the buffer **302** to a signal line **358**. When the valid flag **201** is valid, the packet output from the buffer **302** is preferentially output to the output terminal **359**, and therefore the transmission unit **304** cannot output the packet including the data from the processing unit **1203**. Hence, the transmission unit **304** validates the stall signal via the signal line **354** to suspend the output of the data from the processing unit **1203**. When the valid flag **201** in the packet output from the buffer **302** is invalid, the transmission unit **304** invalidates the stall signal via the signal line **354** and receives the data from the processing unit **1203**. When the valid flag **201** of the packet on the signal line **358** is valid, the selector **303** selects and outputs the output from the buffer **302**.

When the processing unit **1203** can output the data (when the valid signal is valid on the signal line **356**), the transmission unit **304** validates the valid flag **201** on a signal line **362**. Then, the transmission unit **304** generates a packet to which the count value managed therein and the connection ID set in the register are added, and outputs the generated packet to the selector **303** via the signal line **362**. When the valid flag **201** is invalid on the signal line **358**, the selector **303** selects the signal line **362**, i.e. the output from the transmission unit **304**, and transmits the packet generated by the transmission unit **304** to the ring bus **1206** via the output terminal **359**. Although the packet is described herein as being generated, conceptually it means that the data is stored in an empty packet carried over the ring bus **1206**. After the packet is output, the aforementioned count value is incremented.

(Configuration of Reception Unit)

FIG. **6** is a block diagram showing a schematic configuration of the reception unit **301**. As shown in FIG. **6**, the reception unit **301** includes a register **401** (storage unit), a counter **402**, a comparison unit **403**, a determination unit **404** (switch unit), a stall counter **405**, and an erase mode register **406**.

The register **401** stores therein the connection ID. When this connection ID matches the ID **204** in a received packet, it means that the processing unit **1203** connected to the reception unit **301** should process data included in the received packet. The counter **402** manages the order of data to be processed. When the count value **203** in the received packet matches the value in the counter **402**, it means that the received packet includes data that should be processed next by the processing unit **1203** connected to the reception unit **301**.

The comparison unit **403** monitors the valid flag **201**, the stall flag **202**, the ID **204**, and the count value **203** in the received packet. If the valid flag **201** in the received packet is valid, the comparison unit **403** checks, through comparison, whether or not the ID **204** in the received packet matches the connection ID stored in the register **401**, and whether or not the count value in the received packet matches the value in the counter **402**. The comparison unit **403** outputs, to the determination unit **404**, a connection ID match signal if the ID **204** matches the connection ID, and a count value match signal if the count value matches the value in the counter **402**, in "valid" state. Furthermore, if the stall flag **202** in the input packet is valid, the comparison unit **403** outputs a stall valid signal to the determination unit **404**.

The determination unit **404** determines a process to be executed based on the connection ID match signal, the count value match signal, the stall valid signal, the stall signal of the processing unit **1203** via the signal line **353**, the stall counter **405**, and the erase mode register **406**. Here, the stall signal from the signal line **353** indicates whether or not the processing unit **1203** can execute the process. When the stall signal is invalid, it means that the processing unit **1203** can execute the process and therefore import the data.

The stall counter **405** increments the count by one (adds one to the count value) when the reception unit **301** validates the stall flag **202**. The stall counter **405** deducts one from the count value when the packet in which the stall flag **202** was validated is processed later. The stall counter **405** is reset when the operation is started by, for example, turning on the power. The initial value of the stall counter **405** is "0". Therefore, unless the reception unit **301** outputs a suspended packet, the value of the stall counter remains to be "0". That is to say, the stall counter **405** shows the number of packets suspended by the reception unit **301**, or the number of data that has been left unprocessed after the corresponding processing unit **1203** suspended the process.

Note that the communication unit **1202** is allowed to change the value of the stall flag **202** in the received packet only when the value of the stall counter is greater than "0" and the stall flag **202** is valid, or when the stall flag **202** is invalid. More specifically, the stall flag **202** can be changed from valid to invalid only when the value of the stall counter is greater than "0" and the stall flag **202** is valid, and from invalid to valid only when the stall flag **202** is invalid.

When the erase mode is set to be valid or invalid by the control unit **100**, the erase mode register **406** stores therein that setting. The value of the stall counter **405** may be cleared to "0" at timings other than the start of the operation by, for example, being reset under the instruction from the control unit **100** before the data input is started upon switching the mode (upon starting a new process).

(Operations of Reception Unit)

There are two main types of operations executed by the reception unit **301** when receiving a packet having the same ID as the connection ID stored in the register **401**. These two types of operations are: (1) a accepting operation of analyzing the received packet and transmitting data **205** to the processing unit **1203** when the processing unit **1203** can process the data; and (2) a suspending operation of outputting a suspended packet to the buffer **302** when the processing unit **1203** cannot process the data. When receiving a packet having an ID that differs from the connection ID stored in the register **401**, the reception unit **301** outputs the packet stored in the buffer **302** as-is to a neighboring communication unit **1202** (through).

The operation (1) is classified into the following two operations: (1-1) an operation of leaving the value of the stall flag **202** unchanged; and (1-2) an operation of changing the value of the stall flag **202**. The operation (1-1) is classified into the following two operations: (1-1-1) an operation of storing an empty packet in the buffer **302**; and (1-1-2) an operation of storing a valid packet in the buffer **302**. Similarly, the operation (1-2) is classified into the following two operations: (1-2-1) an operation of storing an empty packet in the buffer **302**; and (1-2-2) an operation of storing a valid packet in the buffer **302**. On the other hand, the operation (2) is classified into the following two operations: (2-1) an operation of validating the stall flag **202**; and (2-2) an operation of leaving the stall flag **202** unchanged. The determination unit **404** determines which of these operations is to be selected. These operations are explained below.

(1) Accepting Operation

(1-1) Operation of Leaving Value of Stall Flag **202** Unchanged

This operation is executed when the value of the stall counter **405** is "0". In other words, this operation is executed when the reception unit **301** has not output the suspended packet, or after the data that has once been suspended is all processed.

(1-1-1) Operation of Storing Empty Packet in Buffer **302**

This operation is executed when the value of the stall counter **405** is 0 in the communication unit **1202** in which the erase mode is set to be valid in the state where predetermined conditions are satisfied. The predetermined conditions are: the valid flag included in the received packet is valid; the connection ID match signal and the count value match signal are both valid; the stall valid signal is invalid; and the stall signal is invalid on the signal line **353**.

In order to invalidate the packet in the buffer **302**, this operation executes control to clear the valid flag **201** in the packet stored in the buffer **302** via the signal line **360**. At the same time, a control signal for the stall flag **202** is output to the buffer **302** via the signal line **361**. There are three types of control for the stall flag, namely, set (validate), clear (invalidate), and maintain (do nothing). In the present case, as the value of the stall counter **405** is "0", a control signal for "maintain" is output.

Also, when this operation is executed, the determination unit **404** causes the counter **402** to increment the count value (add one to the count value) in the next clock cycle, so as to acquire data following the data that has been received and transmitted to the processing unit **1203**. For example, the determination unit **404** may notify the counter **402** of a count valid signal in a valid state, and the counter **402** may increment the count value upon receiving that notification. At the same time, the determination unit **404** validates the valid signal on the signal line **351**, and outputs the data **205** included in the packet to the processing unit **1203** via the signal line **352**.

(1-1-2) Operation of Storing Valid Packet in Buffer **302**

This operation is executed when the value of the stall counter **405** is 0 in the communication unit **1202** in which the erase mode is set to be valid in the state where predetermined conditions are satisfied. The predetermined conditions are: the valid flag included in the received packet is valid; the connection ID match signal and the count value match signal are both valid; the stall valid signal is valid; and the stall signal is invalid on the signal line **353**. That is to say, this operation is executed when the received suspended packet has been suspended by another communication unit **1202**, is to be processed by the processing unit **1203** connected to the reception unit **301**, and can be processed by that processing unit **1203**.

This operation is executed also when the value of the stall counter **405** is 0 in the communication unit **1202** in which the erase mode is set to be invalid in the state where predetermined conditions are satisfied. The predetermined conditions are: the valid flag included in the received packet, the connection ID match signal and the count value match signal are all valid; and the stall signal on the signal line **353** is invalid.

In this case, the determination unit **404** maintains the valid state of the valid flag **201** in the buffer **302** without clearing it. The determination unit **404** also "maintains" the stall flag **202** as the value of the stall counter **405** is "0". Other control, such as control for incrementing the count value and outputting data, is similar to the operation (1-1-1) and a description thereof is omitted.

(**1-2**) Operation of Invalidating Stall Flag **202**

This operation is executed when the value of the stall counter **405** is not "0" in the state where predetermined conditions are satisfied. The predetermined conditions are: the valid flag included in the received packet is valid; the connection ID match signal and the count value match signal are both valid; the stall valid signal is valid; and the stall signal on the signal line **353** is invalid.

When the value of the stall counter **405** is greater than "0", it means that the reception unit **301** has output a packet in which the stall flag **202** is valid. In this state, if a packet in which the stall flag **202** is valid is received, the stall flag **202** in the buffer **302** can be invalidated by causing the processing unit **1203** to process data included in that packet. At this time, the determination unit **404** decrements the value of the stall counter **405** (deduct one therefrom) as the processing unit **1203** processes the data included in the packet in which the stall flag **202** is valid. For example, the determination unit **404** may output a count control signal including a countdown instruction to the stall counter **405** and cause the stall counter **405** to decrement the count value in the next clock cycle. Note that the smallest value of the stall counter **405** is "0". Once the value of the stall counter **405** has been decremented to "0", the stall counter **405** maintains the value "0" thereafter.

(2-1) Operation of Storing Empty Packet in Buffer **302**

This operation is executed by a communication unit **1202** in which the erase mode is set to be valid. This operation is substantially the same as the operation (1-1-1). That is to say, this operation invalidates the valid flag **201** in the packet stored in the buffer **302**. However, unlike the operation (1-1-1), the determination unit **404** outputs a control signal for clearing the stall flag **202** in the packet stored in the buffer **302**. Other control, such as control for incrementing the count value and outputting data, is similar to the operation (1-1-1) and a description thereof is omitted.

(1-2-2) Operation of Storing Valid Packet in Buffer **302**

This operation is executed by a communication unit **1202** in which the erase mode is set to be invalid. In this operation, the determination unit **404** outputs a control signal for clearing the stall flag **202** in the packet stored in the buffer **302**, as with the operation (1-2-1). However, the determination unit **404** does not clear the valid flag **201** in the packet stored in the buffer **302**, but maintains the valid state of the valid flag **201**. Other control, such as control for incrementing the count value and outputting data, is similar to the operation (1-1-1) and a description thereof is omitted.

(2) Suspending Operation

When the stall signal via the signal line **353** is valid, the processing unit **1203** cannot import data, and therefore a suspending operation is executed. In this case, the determination unit **404** determines whether or not to set the stall flag **202** in the buffer **302** with reference to the stall valid signal and the value of the stall counter **405**. At the same time, the determination unit **404** invalidates the valid signal on the signal line **351**.

(2-1) Operation of Changing Stall Flag **202**

This operation is executed when the connection ID match signal and the count value match signal are valid, the stall valid signal is invalid, and the stall signal via the signal line **353** is valid. This operation is executed also when the connection ID match signal is valid, the count value match signal and the stall valid signal are invalid, and the value of the stall counter **405** is not 0. In the former case, the stall flag in the received packet is validated because the processing unit **1203** cannot import data included in the received packet. In the latter case, the stall flag in the received packet is validated because it is thought that the reception unit **301** has suspended a packet with a count value previous to the count value of the received packet. In this case, the determination unit **404** outputs a control signal for setting the stall flag **202** in the packet stored in the buffer **302**, as well as a control signal for incrementing the value of the stall counter **405** by one. In this case, the determination unit **404** invalidates the valid signal on the signal line **351** because the processing unit **1203** cannot import data. Furthermore, the value of the counter **402** remains unchanged.

(2-2) Operation of Leaving Stall Flag **202** Unchanged

This operation is executed when the connection ID match signal and the count value match signal are valid, the stall valid signal is valid, and the stall signal via the signal line **353** is valid. In this case, although a suspended packet is output, the determination unit **404** does not change the stall flag **202** because the stall flag **202** is already valid. Furthermore, the value of the stall counter **405** is not incremented, i.e. maintained.

(Configuration of Transmission Unit)

FIG. **7** is a block diagram showing a schematic configuration of the transmission unit **304**. As shown in FIG. **7**, the transmission unit **304** includes a register **501** (storage unit), a counter **502**, and a packet generation unit **503**. The valid flag **201** in the packet output from the buffer **302** is input to the packet generation unit **503** via the signal line **363**. This valid flag **201** is also output to the processing unit **1203** via the signal line **354**. Furthermore, the processing unit **1203** inputs data and a data valid signal (valid signal) to the packet generation unit **503** via the signal lines **355** and **356**, respectively. The packet generation unit **503** outputs the generated packet to the selector **303** via the signal line **362**.

The packet generation unit **503** references the valid signal transmitted from the processing unit **1203** connected thereto via the signal line **356**, and if the valid signal is valid, determines that the data output from the processing unit **1203** is possible. In the case where the packet generation unit **503** has determined that the data output from the processing unit **1203** is possible, if the valid flag **201** on the signal line **354** is invalid, the packet generation unit **503** generates a packet storing therein the count value of the counter **502** and an output connection ID set in the register **501**. At this time, the packet generation unit **503** sets the valid flag and the stall flag in the generated packet to be valid and invalid, respectively, and stores them in the data **205** of the data packet processed by the processing unit **1203** via the signal line **355**. The packet generation unit **503** then outputs the packet to the selector

303. In the next clock cycle, the counter 502 increments the count value (adds one to the count value). Note that the control unit 100 resets the counter 502 of the transmission unit 304 and the counter 402 of the reception unit 301 in the communication unit 1202 to the same value prior to the start of data transfer so as to ensure synchronization.

When the stall flag 202 in the received packet is invalid and the ID 204 in the received packet matches the output connection ID stored in the register 501, the communication unit 1202 considers that the packet it output was not processed in the subsequent stage, invalidates the valid flag 201, and deletes the received packet (turns the received packet into an empty packet). The communication unit 1202 deletes the received packet because the packet it output was not processed in the subsequent stage and no processing was suspend, that is to say, it can be judged that there is no longer any module that should process data included in that packet.

(Operations of Data Path Control Mechanism)

With reference to FIGS. 8A and 8B, the following describes operations of the branch process in the data path control mechanism configured as shown in FIG. 2 using the communication units 1202 pertaining to the present embodiment shown in FIGS. 5 to 7. In FIGS. 8A and 8B, the statuses of the reception units 301 in the communication units 1202-1 to 1202-4 are shown in accordance with processing steps. As the branch process, processes A→B and A→C are executed in parallel. Note that the following description is given under the assumption that the control unit 100 has set the registers 401 and 501 in the communication units 1202-1 to 1202-4 to values for execution of the branch process. Furthermore, the erase mode register 406 is set to be invalid in the communication unit 1202-3 and valid in the other communication units.

Note that in FIGS. 8A and 8B, the numbers enclosed in circles denote valid packets (packets in which the valid flag 201 is valid), the numbers in the circles denote the count value 203 in the packets, and circles with a bold outline denote packets in which the stall flag 202 is valid. The numbers 402, 405, and 353 below the valid packets respectively indicate the value of the counter 402, the value of the stall counter 405, and the state of the stall signal input via the signal line 353. In order to simplify the description, it is assumed here that the processing unit 1203-2 and the input/output unit 1201 can always process data, and the communication units 1202-2 and 1202-1 do not output a suspended packet.

Furthermore, in FIGS. 8A and 8B, the state of the signal line 353 is indicated as "invalid" or "valid", where "invalid" means that the stall valid signal on the signal line 353 is invalid and data can be processed, and "valid" means that the stall valid signal on the signal line 353 is valid and data cannot be processed.

First, the 0th data is input from the input terminal 151 (S0), and a packet including the 0th data is output from the communication unit 1202-1. Upon receiving the packet transmitted from the communication unit 1202-1, the communication unit 1202-2 imports the 0th data included in the received packet as the processing unit 1203-2 can process data (the signal line 353 is invalid). The communication unit 1202-2 adds one to (increments) the value of the counter 402. As a result, the value of the counter 402 is set to "1" (S1). The communication unit 1202-2 transmits the data to the processing unit 1203-2 and outputs an empty packet (S2). The processing unit 1203-2 processes the data (S2). After process A has been executed, the communication unit 1202-2 packetizes the data and outputs the packetized data to the ring bus 1206 (S3). Note that this receiving operation corresponds to the above-described operation (1-1-1).

As the processing unit 1203-3 can process data (the signal line 353 is invalid), the communication unit 1202-3 imports the 0th data, which was processed by the processing unit 1203-2, from the received packet and increments the value of the counter 402 to "1" (S3). As the erase mode is invalid in the communication unit 1202-3, the communication unit 1202-3 transmits the data to the processing unit 1203-3 and outputs the received valid packet to the ring bus 1206 (S4). The processing unit 1203-3 executes process B on the received data (S4). The processed data is output to the communication unit 1202-3. The communication unit 1202-3 packetizes this data and outputs the packetized data to the ring bus 1206 (S5). This operation corresponds to the above-described operation (1-1-2). Thereafter, the packet including this processed data passes through the communication unit 1202-4 (S5). The processed data is output to the output terminal 152 via the communication unit 1202-1, and the packet is deleted (S6). It is assumed here that after executing process B, the processing unit 1203-3 becomes incapable of processing data (the signal line 353 becomes valid).

As the processing unit 1203-4 can process data (the signal line 353 is invalid), the communication unit 1202-4 imports the packet including the 0th data that was processed by the processing unit 1203-2, and increments the value of the counter 402 to "1" (S4). The processing unit 1203-4 executes process C on the data imported by the communication unit 1202-4, and returns the processed data to the communication unit 1202-4 (S5). The communication unit 1202-4 packetizes the received data and outputs the packetized data to the ring bus 1206. Note that as the communication unit 1202-4 transfers the packet received from the communication unit 1202-3 in S6, the packet including the data on which process C was executed is output to the ring bus 1206 in S7. This operation corresponds to the above-described operation (1-1-1). The processed data in the output packet is output to the output terminal 152 via the communication unit 1202-1, and the packet is deleted (S7).

A description is now given of a packet including the 1st data (a packet whose count value 203 is 1). The 1st data is input from the input terminal 151 and packetized by the communication unit 1202-1 in S3. The 1st data is then output to the ring bus 1206 (S4). As the processing unit 1203-2 can process data, the communication unit 1202-2 imports the data from this packet and increments the value of the counter 402 to "2" (S4). Then, the imported data is output to the processing unit 1203-2. The processing unit 1203-2 executes process A on this data (S5). The processed data is input to the communication unit 1202-2. The communication unit 1202-2 packetizes this data and outputs the packetized data to the ring bus 1206 (S6). Note that this receiving operation also corresponds to the above-described operation (1-1-1).

As the processing unit 1203-3 cannot process data (the signal line 353 is valid), the communication unit 1202-3 cannot import the packet including the 1st data that was processed by the processing unit 1203-2 (S6). Therefore, the communication unit 1202-3 increments the value of the stall counter 405 to "1" and validates the stall flag 202 in the packet in the buffer 302 (S6). This operation corresponds to the above-described operation (2-1).

As the processing unit 1203-4 can process data, the communication unit 1202-4 imports the packet including the 1st data that was processed by the processing unit 1203-2, and increments the value of the counter 402 to "2" (S7). Then, the communication unit 1202-4 inputs the imported data to the processing unit 1203-4, and outputs the packet in the buffer 302 to the ring bus 1206 without changing the valid flag 201 and the stall flag 202 (S8). This operation corresponds to the above-described operation (1-1-2). The processing unit **1203-4** executes process C on the input data and returns the processed data to the communication unit **1202-4** (S**8**). The communication unit **1202-4** packetizes the processed data and outputs the packetized data to the ring bus **1206**. The processed data is output to the output terminal **152** via the communication unit **1202-1** and deleted (S**9**).

It is assumed here that, in parallel with the 1st data, the 2nd data is input from the input terminal **151** in S**6**. The input data is packetized by the communication unit **1202-1** and output to the ring bus **1206** (S**7**). As the processing unit **1203-2** can process data, the communication unit **1202-2** imports data from this packet and increments the value of the counter **402** to "3" (S**7**). Then, the imported data is output to the processing unit **1203-2**. The processing unit **1203-2** executes process A on this data (S**8**). The processed data is input to the communication unit **1202-2**. The communication unit **1202-2** packetizes this data and outputs the packetized data to the ring bus **1206** (S**9**). Note that this receiving operation also corresponds to the above-described operation (1-1-1).

It is assumed here that the processing unit **1203-3** became capable of processing data in S**8**. As the processing unit **1203-3** can process data, the communication unit **1202-3** compares the ID and the count value in the received packet with the values stored in the communication unit **1202-3**. In this case, however, the count value **203** in the received packet (2) differs from the value of the counter **402** (1). Here, the value of the stall counter **405** is incremented to "2" because the connection ID match signal is valid, the count value match signal and the stall valid signal are invalid, and the stall counter is not 0 (S**9**). After the stall flag **202** in the packet in the buffer **302** is validated, this packet is output to the ring bus **1206**. This operation corresponds to the above-described operation (2-1).

Thereafter, the communication unit **1202-3** receives the packet including the **1**st data, which was suspended earlier (S**10**). As the processing unit **1203-3** can process data at this point, the count value is incremented and the stall count is decremented. Furthermore, the stall flag **202** in the packet stored in the buffer **302** is cleared. However, the valid flag is not cleared. This operation corresponds to the above-described operation (1-2-2). Then, the data is extracted from this packet and output to the processing unit **1203-3**. The processing unit **1203-3** executes process B on this data (S**11**) and returns the processed data to the communication unit **1202-3**. The communication unit **1202-3** packetizes the received processed data and outputs the packetized data to the ring bus **1206** (S**12**). After this packet passes through the communication unit **1202-4** (S**12**), it is output from the output terminal **152** via the communication unit **1202-1** and then deleted (S**13**). When the branch packet in which the stall flag **202** has been cleared reaches the communication unit **1202-2**, it is deleted (the valid flag is cleared) (S**13**). This is because the communication unit **1202-2** considers that the packet it output was not processed in the subsequent stage since the stall flag **202** is invalid and the ID **204** matches the output connection ID stored in the register **501**.

Furthermore, the communication unit **1202-4** receives the packet including the 2nd data, which was suspended by the communication unit **1202-3** and output to the ring bus **1206** (S**10**). It is assumed here that the processing unit **1203-4** became incapable of processing data in S**8**. In this case, the above-described operation (2-2) is executed because the connection ID match signal, the count value match signal and the stall valid signal are all valid and the stall signal from the processing unit **1203-4** is valid. That is to say, the communication unit **1202-4** outputs the packet in the buffer **302** to the ring bus **1206** without changing the stall flag **202**, and the value of the stall counter **405** is maintained (S**10**).

After the packet including the 2nd data passes through the communication units **1202-1** and **1202-2** (S**11**, S**12**), it is received by the communication unit **1202-3**. As the processing unit **1203-3** can process data, the communication unit **1202-3** imports the 2nd data from the received packet and increments the value of the counter **402** to "3" (S**13**). The stall counter **405** is decremented. After the stall flag **202** in the packet stored in the buffer **302** is invalidated, this packet is output to the ring bus **1206** without changing the valid flag (S**14**). This operation corresponds to the above-described operation (1-2-2).

The data imported by the communication unit **1202-3** is output to the processing unit **1203-3**. The processing unit **1203-3** executes process B on this data (S**14**). The processing unit **1203-3** outputs the processed data to the communication unit **1202-3**. The communication unit **1202-3** packetizes the processed data and outputs the packetized data to the ring bus **1206** (S**16**). Thereafter, the processed data in this packet is output to the output terminal **152** via the communication units **1202-4** and **1202-1**, and this packet is deleted (S**17**). This packet was not transmitted in S**15** because the valid packet including the **3**rd data was stored in the buffer **302** and preferentially transmitted.

Note that the packet in which the stall flag **202** was invalidated in S**13** is received by the communication unit **1202-4** (S**14**). The communication unit **1202-4** imports data from this packet because the valid flag in this packet, the connection ID match signal and the count value match signal are all valid, the stall valid signal is invalid, and the processing unit **1203-4** can process data. The value of the counter **402** is incremented to "3" (S**14**). This operation corresponds to the above-described operation (1-1-1). Then, the imported data is output to the processing unit **1203-4**. The processing unit **1203-4** executes process C on this data (S**15**). The processed data is input to the communication unit **1202-4**. The communication unit **1202-4** packetizes this data and outputs the packetized data to the ring bus **1206** (S**20**). Note that this packet was not output to the ring bus **1206** in S**16** to S**19** because valid packets were consecutively input to the buffer **302** and preferentially output. The packet output to the ring bus **1206** is received by the communication unit **1202-1**. After the data included in this packet is output to the output terminal **152**, this packet is deleted.

In S**10**, the **3**rd data is input from the input terminal **151**. The communication unit **1202-1** packetizes this data and outputs the packetized data to the ring bus **1206** (S**11**). As the processing unit **1203-2** can process data, the communication unit **1202-2** imports the packet including the 3rd data and increments the value of the counter **402** to "4". This operation also corresponds to the above-described operation (1-1-1). The communication unit **1202-2** imports the data from this packet and outputs the data to the processing unit **1203-2**. The processing unit **1203-2** executes process A on the data and returns the processed data to the communication unit **1202-2** (S**12**). The communication unit **1202-2** packetizes the received data and outputs the packetized data to the ring bus **1206** (S**14**). Note that this packet was not output in S**13** because the packet including the 2nd data, which was suspended by the communication unit **1202-3**, was preferentially output.

As the processing unit **1203-3** can process data, the communication unit **1202-3** imports the packet including the 3rd data and increments the value of the counter **402** to "4". The communication unit **1202-3** outputs the imported data to the processing unit **1203-3**. The processing unit **1203-3** executes process B on this data (S15). As the erase mode is invalid in the communication unit **1202-3**, the communication unit **1202-3** maintains the valid flag in the packet stored in the buffer **302** as-is and outputs this packet to the ring bus **1206** (S15). This operation corresponds to the above-described operation (1-1-2). The processed data is returned to the communication unit **1202-3**. The communication unit **1202-3** packetizes this data and outputs the packetized data to the ring bus **1206** (S17). The packet output to the ring bus **1206** is received by the communication unit **1202-1**. After the data included in this packet is output to the output terminal **152**, this packet is deleted (S18).

The communication unit **1202-4** receives the packet for the branch process, which was output from the communication unit **1202-3** (S15). It is assumed here that, after the operation of S14, the processing unit **1203-4** became incapable of processing data. As the processing unit **1203-4** cannot process data, the communication unit **1202-4** cannot import the data included in the received packet. Therefore, the value of the stall counter **405** is incremented to "1". After the stall flag **202** in the packet stored in the buffer **302** is validated, this packet is output to the ring bus **1206** (S16). This operation corresponds to the above-described operation (2-1).

The packet including the 3rd data, which was suspended by the communication unit **1202-4**, passes through the communication units **1202-1** to **1202-3** (S16 to S18), and is received by the communication unit **1202-4** again (S19). It is assumed here that the processing unit **1203-4** became capable of processing data before receiving the packet. As the processing unit **1203-4** can process data, the communication unit **1202-4** imports the data included in the packet, increments the count value, and decrements the stall count (S19). At this time, as the erase mode is valid in the communication unit **1202-4**, the communication unit **1202-4** invalidates the valid flag in the packet stored in the buffer **302**. This operation corresponds to the above-described operation (1-2-1). The imported data is input to the processing unit **1203-4**. The processing unit **1203-4** executes process C on this data (S**20**). The processed data is returned to the communication unit **1202-4**. The communication unit **1202-4** packetizes this data and outputs the packetized data to the ring bus **1206** (not shown in the figures).

The packets including the 4th data and the 5th data are processed in a similar manner as the above-described operations. As set forth above, by identifying a communication unit **1202** that executed the suspending operation based on the value of the stall counter **405**, a suspended packet output from a module is not deleted by modules in other branches. In this way, the branch process can be normally executed in a data path control mechanism using a ring bus. It suffices for the stall counter **405** to have the number of bits that allows counting from the state where there is no suspended packet (the count value is "0") through the state where all the empty packets on the ring bus have been expelled. For example, in the present embodiment, it suffices for the stall counter **405** to have 3 bits as there are four communication units **1202** on the ring bus **1206**.

<Second Embodiment>

A description is now given of the second embodiment as one embodiment of the present invention. In the second embodiment, an information processing apparatus and a data processing unit therein have the configurations shown in FIGS. **1** and **2** as with the first embodiment.

(Data Structure of Packet)

FIG. **9** shows a data structure of a packet carried over a ring bus **1206**. The components of FIG. **9** that have the same functions as those in FIG. **2** pertaining to the first embodiment are given the same reference signs thereas, and a description thereof is omitted. FIG. **9** differs from FIG. **2** in that the stall flag **202** is replaced by a stall ID **802**. The stall ID **802** is an area for storing a number of a branch from which a suspended packet has been output. For example, in the case of a branch process where processes A→B and A→C are executed, there are two branches, namely processes B and C. In order to identify these branches, the branch numbers are stored in stall ID registers **1005** in communication units **1202**. The stall ID registers **1005** will be described later. Therefore, in this case, the stall ID **802** may be any information for identifying in which one of processes B and C the process was suspended. For the sake of explanation, "1", "1", "2", and "3" are respectively stored in correspondence with the branches of input/output, process A, process B, and process C. When a suspended packet is output from each branch, the branch number in the corresponding stall ID register **1005** is stored in the stall ID **802** of the packet. Note that when the stall ID **802** is "0", it means that the packet is not the suspended packet.

In the present embodiment, the communication units **1202** have the configuration shown in FIG. **5** as with the first embodiment. However, in the present embodiment, a signal line **361** is used to set the stall ID **802** in the packet stored in the buffer **302**.

(Configuration and Operations of Reception Unit)

FIG. **10** shows the configuration of a reception unit **301** pertaining to the present embodiment. The reception unit **301** of the present embodiment differs from that of the first embodiment in the following points: the reception unit **301** includes the stall ID register **1005** in place of the stall counter **405**; wiring of a comparison unit **403** and a determination unit **404**; and operations of the comparison unit **403** and the determination unit **404**. In the present embodiment, the reception unit **301** can invalidate the stall ID **802** in a packet stored in a buffer **302** only when the stall ID **802** in the received packet matches the branch number in the stall ID register **1005**.

Although the comparison unit **403** in the reception unit **301** monitors whether or not the stall flag **202** is invalid in the first embodiment, it monitors whether or not the stall ID **802** is "0" in the present embodiment. Note that the operations executed when the stall ID **802** is "0" match the operations executed when the stall flag **202** is invalid in the first embodiment. On the other hand, when the stall ID **802** is not "0", if the stall ID **802** in the received packet matches the value stored in the stall ID register, the comparison unit **403** outputs a stall ID match signal in "valid" state to the determination unit **404**. Note that the stall valid signal is valid when the stall ID is not "0".

The determination unit **404** outputs a control signal for the stall ID **802** to the buffer **302** via the signal line **361**. As to the types of control, control for clearing and control for maintenance are similar to those of the first embodiment, but control for setting is to write the value stored in the stall ID register **1005** to the stall ID **802** in the packet. Furthermore, as the stall counter **405** is not provided in the present embodiment, control signals for incrementing/decrementing the count value are not output.

As to the operations of the determination unit **404**, the operation (1-1) is similar as in the first embodiment. On the other hand, the operation (1-2) is executed when the stall ID match signal is valid. When the stall ID match signal is valid, it means that the reception unit **301** has received a packet that was suspended by itself. Therefore, data included in this packet is output to the corresponding processing unit **1203**, and the stall ID **802** in the packet stored in the buffer **302** is cleared (invalidated). Whether to invalidate or maintain the valid flag is determined based on whether the erase mode is valid or invalid, as with the above-described operations (1-2-

1) and (1-2-2). As with the first embodiment, the operation (2-1) is executed when the connection ID match signal and the count value match signal are valid, the stall valid signal is invalid, and the stall signal via the signal line **353** is valid. However, unlike the first embodiment, when the connection ID match signal is valid and the count value match signal and the stall valid signal are invalid, the operation (2-1) is executed if the stall ID match signal is valid. That is to say, the condition that the stall counter **405** is other than "0" in the first embodiment is replaced by the condition that the stall ID match signal is valid in the present embodiment. The value stored in the stall ID register **1005** is written to the stall ID **802** in the packet stored in the buffer **302**. On the other hand, the operation (2-2) is similar as in the first embodiment.

The communication units **1202** are allowed to change the value of the stall ID **802** only when the stall ID **802** is 0 or when the stall ID **802** matches the branch number stored in the stall ID register **1005**.

More specifically, when the stall ID **802** is 0, the communication units **1202** are allowed to change the value of the stall ID **802** to the branch number stored in the stall ID register **1005**. When the stall ID **802** matches the branch number stored in the stall ID register **1005**, the communication units **1202** are allowed to change the value of the stall ID **802** to 0 by clearing it.

(Configuration of Transmission Unit)

In the present embodiment, a transmission unit **304** has the configuration shown in FIG. **7** as with the first embodiment. The operations of the transmission unit **304** are similar as in the first embodiment. However, when packetizing data output from the corresponding processing unit **1203**, the transmission unit **304** sets the stall ID **802** to "0".

(Operations of Data Path Control Mechanism)

A description is now given of operations of the branch process of the data path control mechanism pertaining to the second embodiment with reference to FIGS. **11**A and **11**B. As the branch process, processes A→B and A→C are executed in parallel. The following description is given under the assumption that the control unit **100** has set the values of the registers **401** and **501** in the communication units **1202-1** to **1202-4** to values for realizing the branch process. Furthermore, the erase mode register **406** is set to be invalid in the communication unit **1202-3**, and the erase mode is set to be valid in the other communication units **1202**. In addition, the branch numbers 1, 1, 2, and 3 are respectively set in the stall ID registers **1005** of the communication units **1202-1** to **1202-4**.

In FIGS. **11**A and **11**B, circles with the numbers denote valid packets (in which the valid flag **201** is valid), the numbers in the circles denote the count values **203** of packets, and the circles with a bold outline denote packets in which the stall ID **802** is other than "0". The expression "X-Y" in the circles with a bold outline denotes packets which include the Xth data and in which the stall ID **802** is Y. Filled circles denote empty packets. The numbers **402** and **353** below the valid packets respectively indicate the value in the counter **402** and the state of the stall signal input via the signal line **353**. In order to simplify the description, it is assumed here that the processing unit **1203-2** and the input/output unit **1201** can always process data, and the communication units **1202-2** and **1202-1** do not output a suspended packet.

The operations of S**200** to S**205** are similar to those of S**0** to S**5** in FIG. **8**A. In S**206**, the processing unit **1203-3** judges that the stall signal is valid. At this time, the operation for incrementing the value in the stall counter **405** is not executed because there is no stall counter **405** in the present embodiment. However, the stall ID **802** in the packet output in S**207** is set to "2", which is the value stored in the stall ID register **1005** of the communication unit **1202-3**. Therefore, in FIG. **11**A, the number "1-2" is shown in the packet with a bold outline that arrives at the communication unit **1202-4** in S**207**. In the subsequent processes, when suspension occurs, the value stored in the stall ID register **1005** in the communication unit **1202** is written to the stall ID **802** in the packet in a similar manner. As set forth above, as opposed to the first embodiment in which the value of the stall counter **405** is incremented, the stall ID **802** in the packet stored in the buffer **302** is set to the value stored in the stall ID register **1005** in the present embodiment. Similarly, in the present embodiment, when the stall ID **802** in the received packet matches the value stored in the stall ID register **1005**, control is executed to process data included in this packet and clear the stall ID. At this time, the internal state of the communication units **1202** does not change unlike the case of the first embodiment in which the value of the stall counter **405** is decremented. As has been described above, although the operations of the second embodiment differ from those of the first embodiment in relation to the stall ID **802** and the stall counter **405**, other operations of the second embodiment are substantially similar to those of the first embodiment. Therefore, a description of other steps is omitted.

As set forth above, a complicated branch process that involves outputting a suspended packet can be realized by allowing identification of modules and branches that have output the suspended packet. An increase in the number of modules and the number of branches on the ring bus can be easily accommodated by increasing the number of bits in the stall counter or the number of bits of the stall ID. In this way, the present embodiment makes it possible to accommodate a complicated branch process with the use of simple hardware.

The present invention can provide an information processing apparatus, a communication method and storage medium that can execute a branch process without losing data in a data path control mechanism where a plurality of processing units are connected by a ring-shaped bus.

<Other Embodiments>

Aspects of the present invention can also be realized by a computer of a system or apparatus (or devices such as a CPU or MPU) that reads out and executes a program recorded on a memory device to perform the functions of the above-described embodiment(s), and by a method, the steps of which are performed by a computer of a system or apparatus by, for example, reading out and executing a program recorded on a memory device to perform the functions of the above-described embodiment(s). For this purpose, the program is provided to the computer for example via a network or from a recording medium of various types serving as the memory device (e.g., computer-readable storage medium).

While the present invention has been described with reference to exemplary embodiments, it is to be understood that the invention is not limited to the disclosed exemplary embodiments. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures and functions.

This application claims the benefit of Japanese Patent Application No. 2011-202334 filed on Sep. 15, 2011, which is hereby incorporated by reference herein in its entirety.

What is claimed is:

1. An information processing apparatus including a plurality of communication units connected to one another in a ring shape by a bus, each of the plurality of communication units being connected to one of a plurality of processing units, each of which executes a predetermined process, and transmitting data processed by the one of the plurality of processing units to the bus as a packet, the information processing apparatus performing sequential processing of the data by causing the plurality of processing units to perform the predetermined process in a predetermined order,

wherein among the plurality of communication units, at least one communication unit comprises:

a reception unit configured to receive a packet wherein the packet can hold data and a flag indicating whether or not a process has been stalled;

a determination unit configured to determine whether or not the flag of the received packet indicates that the process has been stalled;

a storage unit configured to store information indicating a number of packets in which a flag, indicating the process has been stalled according to a determination by the determination unit, is not changed; and

a transmission unit configured to transmit a packet,

wherein the transmission unit transmits, in a case where a processing unit connected with a self-communication unit stalled a process for data included in the received packet to be processed by the processing unit, the data with the flag indicating the process has been stalled to the bus,

wherein the information stored in the storage unit is a value that is increased by one in accordance with the processing unit connected with the self-communication unit having stalled the process for the data to be processed, and that is decreased by one in accordance with data held in the received packet having been processed by the processing unit connected with the self-communication unit and in which the flag of the received packet indicates the process has been stalled, and

wherein the determination unit can change the flag of the received packet based on the information in the storage unit.

2. The information processing apparatus according to claim **1**, wherein when a received packet includes information indicative of suspension of a process and the information stored in the storage unit shows that the number is zero, the at least one communication unit transmits the received packet as-is to the bus.

3. The information processing apparatus according to claim **2**, wherein when a received packet includes information indicative of suspension of a process, the information stored in the storage unit shows that the number is greater than zero, and the connected processing unit should process data included in the received packet, the at least one communication unit outputs the data included in the received packet to the connected processing unit and transmits the received packet as-is to the bus.

4. The information processing apparatus according to claim **1**, wherein when a received packet includes information indicative of suspension of a process and the information stored in the storage unit shows that the number is greater than zero, the determination unit of the at least one communication unit determines to output data included in the received packet to the connected processing unit, invalidate the received packet, and transmit the invalidated received packet to the bus.

5. The information processing apparatus according to claim **1**, wherein when a received packet includes information indicative of suspension of a process and the information stored in the storage unit shows that the number is greater than zero, the determination of the at least one communication unit determines to output data included in the received packet to the connected processing unit, invalidate the information indicative of suspension of the process included in the received packet, and transmit the received packet to the bus.

6. The information processing apparatus according to claim **1**, wherein the storage unit is a counter that performs counting in conjunction with determination, by the determination unit, of setting a flag indicating whether or not a process has been stalled for the received packet.

7. The information processing apparatus according to claim **6**, wherein when receiving a packet including information indicative of suspension of a process in a state where the number of packets that are left unprocessed is greater than 0, the storage unit of the at least one communication unit deducts one from a value of the counter upon the connected processing unit processing data included in the received packet.

8. The information processing apparatus according to claim **6**, wherein the storage unit of the at least one communication unit sets a value of the counter to 0 when data input is started.

9. The information processing apparatus according to claim **1**, wherein only when a received packet includes information indicative of suspension of a process and the information stored in the storage unit shows that the number is greater than zero, or when a received packet does not include information indicative of suspension of a process, the determination unit of the at least one communication unit is allowed to determine to change the information indicative of suspension of the process from valid to invalid, or from invalid to valid.

10. A communication method used in an information processing apparatus including a plurality of communication units connected to one another in a ring shape by a bus, each of the plurality of communication units being connected to one of a plurality of processing units, each of which executes a predetermined process, and transmitting data processed by the one of the plurality of processing units to the bus as a packet, the information processing apparatus performing sequential processing of the data by causing the plurality of processing units to perform the predetermined process in a predetermined order,

wherein in at least one communication unit among the plurality of communication units, the communication method comprises:

receiving, by a reception unit, a packet wherein the packet can hold data and a flag indicating whether or not a process has been stalled;

determining, by a determination unit, whether or not the flag of the received packet indicates that the process has been stalled;

storing, by a storage unit, information indicating a number of packets in which a flag, indicating the process has been stalled according to a determination by the determination unit, is not changed; and

transmitting, by a transmission unit, a packet,

wherein the transmission unit transmits, in a case where a processing unit connected with a self-communication unit stalled a process for data included in the received packet to be processed by the processing unit, the data with the flag indicating the process has been stalled to the bus,

wherein the information stored in the storage unit is a value that is increased by one in accordance with the processing unit connected with the self-communication unit having stalled the process for the data to be processed, and that is decreased by one in accordance with data held in the received packet having been processed by the processing unit connected with the self-communication unit and in which the flag of the received packet indicates the process has been stalled, and

wherein in the determining step, the flag of the received packet can be changed based on the information in the storage unit.

11. A non-transitory computer-readable storage medium storing a computer program for causing a computer to execute steps in an information processing apparatus including a plurality of communication units connected to one another in a ring shape by a bus, each of the plurality of communication units being connected to one of a plurality of processing units, each of which executes a predetermined process, and transmitting data processed by the one of the plurality of processing units to the bus as a packet, the information processing apparatus performing sequential processing of the data by causing the plurality of processing units to perform the predetermined process in a predetermined order,

wherein in at least one communication unit among the plurality of communication units, the steps comprise:

receiving, by a reception unit, a packet wherein the packet can hold data and a flag indicating whether or not a process has been stalled;

determining, by a determination unit, whether or not the flag of the received packet indicates that the process has been stalled;

storing, by a storage unit, information indicating a number of packets in which a flag, indicating the process has been stalled according to a determination by the determination unit, is not changed; and

transmitting, by a transmission unit, a packet,

wherein the transmission unit transmits, in a case where a processing unit connected with a self-communication unit stalled a process for data included in the received packet to be processed by the processing unit, the data with the flag indicating the process has been stalled to the bus,

wherein the information stored in the storage unit is a value that is increased by one in accordance with the processing unit connected with the self-communication unit having stalled the process for the data to be processed, and that is decreased by one in accordance with data held in the received packet having been processed by the processing unit connected with the self-communication unit and in which the flag of the received packet indicates the process has been stalled, and

wherein in the determining step, the flag of the received packet can be changed based on the information in the storage unit.

12. An information processing apparatus including at least a first processing unit and a second processing unit, comprising:

a first communication unit configured to connect with a ring bus, set, if the first processing unit connected with the first communication unit does not process first data to be processed by the first processing unit wherein the first data is included in a received packet, a flag of the received packet which includes the first data wherein the flag indicates a process for the first data has been stalled, and transmit the received packet to the ring bus; and

a second communication unit configured to connect with a ring bus, set, if the second processing unit connected with the second communication unit does not process the first data to be processed by the second processing unit wherein the first data is included in a received packet, a flag of the received packet which includes the first data wherein the flag indicates a process for the first data has been stalled, and transmit the received packet to the ring bus,

wherein the first communication unit comprises a storage unit configured to store, if the first communication unit receives a packet including the first data and the flag indicating a process for the first data has been stalled being set, information for identifying whether or not the received packet is a packet for which the flag indicating a process for the first data has been stalled has been set by the first communication unit,

wherein the first communication unit further comprises a transmission unit configured to transmit a packet and, in a case where the first processing unit connected with a self-communication unit stalled a process for data included in the received packet to be processed by the first processing unit, the data with the flag indicating the process has been stalled to the bus,

wherein the information stored in the storage unit is a value that is increased by one in accordance with the first processing unit connected with the self-communication unit having stalled the process for the data to be processed, and that is decreased by one in accordance with data held in the received packet having been processed by the first processing unit connected with the self-communication unit and in which the flag of the received packet indicates the process has been stalled, and

wherein the first communication unit change the flag based on the information stored in the storage unit.

13. The information processing apparatus according to claim 12, wherein the first communication unit can change the flag in a case that the information stored in the storage unit indicates that the received packet is a packet for which the flag indicating a process has been stalled has been set by the first communication unit.

14. A communication method used in an information processing apparatus including at least a first processing unit and a second processing unit, each of which is configured to connect with a ring bus, the method comprising:

setting, by a first communication unit, if the first processing unit connected with the first communication unit does not process first data to be processed by the first processing unit wherein the first data is included in a received packet, a flag of the received packet which includes the first data wherein the flag indicates a process for the first data has been stalled,

transmitting, by the first communication unit, the received packet to the ring bus;

setting, by a second communication unit, if the second processing unit connected with the second communication unit does not process the first data to be processed by the second processing unit wherein the first data is included in a received packet, a flag of the received packet which includes the first data wherein the flag indicates a process for the first data has been stalled;

transmitting, by the second communication unit, the received packet to the ring bus; and

storing, by a storage unit in the first communication unit, if the first communication unit receives a packet including the first data and the flag indicating a process for the first data has been stalled being set, information for identifying whether or not the received packet is a packet for which the flag indicating a process for the first data has been stalled has been set by the first communication unit,

wherein the first communication unit, in a case where the first processing unit connected with a self-communication unit stalled a process for data included in the received packet to be processed by the first processing unit, transmits the data with the flag indicating the process has been stalled to the ring bus, and

wherein the information stored in the storage unit is a value that is increased by one in accordance with the first processing unit connected with the self-communication unit having stalled the process for the data to be processed, and that is decreased by one in accordance with data held in the received packet having been processed by the first processing unit connected with the self-communication unit and in which the flag of the received packet indicates the process has been stalled.

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